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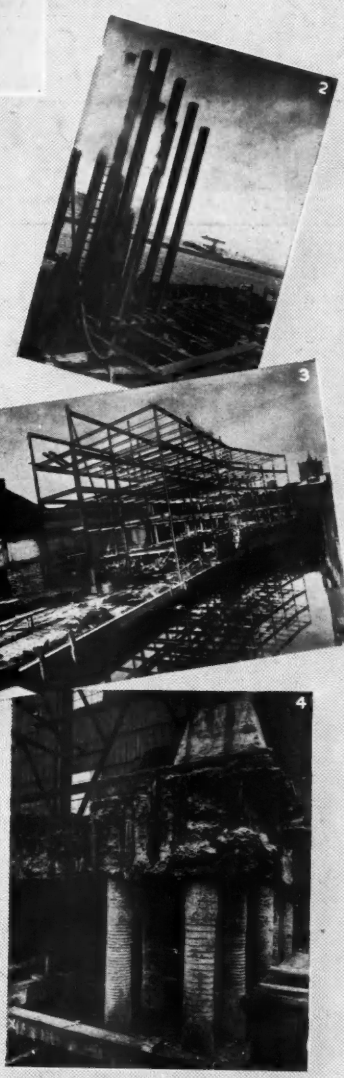

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A Seven-Day Journal

Thames Drainage Schemes

REFERENCE to schemes prepared under war-time legislation for the drainage of land for agricultural purposes was made at a recent meeting of the Thames Conservancy Board. The Chairman of the Board, Captain Jocelyn Bray, said that a scheme which had been prepared for Oxfordshire would involve the clearing of some 20 to 25 miles of watercourses, which would prove beneficial to 2300 acres of agricultural land. The cost of the scheme, which was the first to be worked out and put before the Ministry of Agriculture by any catchment authority under the 1940 Act, would, it was estimated, be £2500, or £1 1s. 9d. per acre, half of which would be met by the Government and half charged to the owners. A similar scheme had been prepared for Surrey, the cost of which would be about £2770, and would deal with 3323 acres. Lord Phillimore, who is the chairman of the special committee set up to deal with the drainage of agricultural land, reported that the war agricultural committees of no less than fifteen counties had expressed their willingness to co-operate with the Thames Conservancy Board. The committees referred to were those of Bedfordshire, Berks, Bucks, Gloucestershire, Hampshire, Herts, Middlesex, Northants, Oxfordshire, Surrey, East Sussex, West Sussex, Warwickshire, Wilts, and Worcestershire. There was some difficulty in obtaining the labour desired, but Lord Phillimore expressed the hope that real progress with the schemes would soon be made.

Call for Skilled Labour

BRITAIN'S engineering shops were asked on Saturday, July 20th, by the three Supply Ministers to take immediate steps to increase the national supply of skilled labour. The appeal was made in a letter, which we reprint on page 64, signed by Mr. A. V. Alexander, First Lord of the Admiralty; Mr. Herbert Morrison, Minister of Supply, and Lord Beaverbrook, Minister of Aircraft Production, which has been sent to 9000 firms. Skilled men are now urgently needed. New factories are coming into production and many plants formerly working only one shift now run continuously day and night. The present demand for skilled labour already exceeds the available supply, and this demand is rapidly increasing. A Ministry of Supply announcement states that to benefit fully from the great step forward in potential production that has been achieved, the paramount need is for immediate measures by industry to augment the action being taken by the Minister of Labour and National Service to train new recruits and "train up" those already at work. To meet this need, the three Supply Ministers have asked in their letter that the 9000 main contractors working for them should adopt new measures in their own workshops. Though they have sent their message only to the main contractors, it is the Ministers' hope that every sub-contractor and, indeed, every firm in the industries concerned, whether or not engaged on war work, will do all in their power to meet the urgent need. They are urged to assist in the reorganisation of man power in their industries by grading, so that each skilled engineer is employed on work of the maximum skill of which he is capable; by "training up" existing staffs, so that unskilled or semi-skilled workers may be moved to more highly skilled work; by training new entrants to industry; by providing facilities in the workshops for handling the greatest possible number of recruits; and by other steps.

Fast Italian Cruiser Sunk

ON Friday, July 19th, it was reported by the Commander-in-Chief of the Mediterranean Fleet that the British cruiser H.M.A.S. "Sydney," under the command of Captain J. A. Collins, R.A.N., accompanied by a small destroyer force, became engaged with two Italian cruisers in the early morning to the north-westward of the Island of Crete. In the ensuing action the fast 6in. gun Italian cruiser "Bartolomeo Colleoni" was sunk. The destroyer H.M.A.S. "Voyager" also sunk an Italian submarine. The other Italian cruiser withdrew, with the British forces in pursuit. The Prime Minister has conveyed to Mr. Menzies, the Prime Minister of Australia, and the Australian Naval Board, his warmest congratulations on the action, which, he says, recalls the most opportune exploit of her predecessor in sinking the "Emden" in the last war. The "Bartolomeo Colleoni" was an interesting ship as she was classed as one of the fastest naval ships of her type afloat. She was one of four ships of the "Condottieri A" class, which were designed as a reply to the French destroyers of the "Lion" type. This type of cruiser was specially built to be capable of overtaking the fastest destroyer, and on the trials, which were carried out by Ansaldo, very shortly after she had been launched with all her funnels and masts in position, her sister ship, the "Alberico da Barbiano," reached the record speed of 42·04 knots at a displacement of 5607 tons, and maintained a speed of 39·74 knots for eight hours with her full armament aboard. The "Bartolomeo Colleoni" was also built and engined at the Ansaldo yard and attained on trials a speed of 40·9 knots. Her hull particulars were as follows:—Length overall, 555·5ft.; beam, 50ft. 2in., and mean draught, 14ft. 6in. Her armament comprised eight 6in. guns; six 3·9in., eight 37 mm., and eight 13 mm., all anti-aircraft guns; and four 21in. torpedo tubes, above water, all paired. Two aircraft, with a catapult of the Magaldi pattern arranged along the forecastle, were carried. The propelling machinery comprised a twin-screw arrangement of Belluzzo geared turbines, taking steam from six three-drum boilers of the oil-fired type. The designed output of the machinery was about 95,000 S.H.P., corresponding to a normal speed of 37 knots.

National Arbitration Tribunal

AFTER consultation with the National Joint Advisory Council, representative of the British Employers' Confederation and the Trades Union Congress, Mr. Ernest Bevin, the Minister of Labour and National Service, has made an Order under the Defence Regulations, entitled the Conditions of Employment and National Arbitration Order, 1940, which came into force on Thursday, July 25th. The Order relates to the settlement of trade disputes, the prevention of strikes and lockouts, the observance of recognised terms and conditions of employment and the recording of departures from trade practices. While retaining and requiring the full use of the existing voluntary arrangements for the settlement of trade disputes, the new Order sets up a National Arbitration Tribunal, to which trade disputes reported to the Minister and not otherwise settled will be referred. Strikes and lockouts are prohibited, unless the dispute has been reported to the Minister and twenty-one days have elapsed without reference of the dispute by the Minister for settlement in accordance with the Order. The Order also requires the observance by all employers of terms and conditions of employment not less favourable than the recognised terms and conditions settled by machinery of negotiation or arbitration. Provision is made for the reference to the Tribunal of any question as to the meaning of recognised terms and conditions in a particular case, if such a question is reported by an employers' organisation or trade union which habitually takes part in the settlement of wages and working conditions in the trade or industry concerned. The Order also lays down procedure under which memoranda recording particulars of trade practices and departures therefrom may be made by employers, employers' organisations and trade unions and deposited for consultation at the local office of the Ministry. The National Arbitration Tribunal will consist of five persons, three being appointed members, of whom one will be the chairman. The two other members will be selected from panels of employers' and workers' representatives, for each sitting of the Tribunal. After consulting with the Lord Chancellor the Minister has appointed Mr. Justice Gavin Simonds to be the Chairman of the Tribunal, and Sir John Forster and Sir Hector Hetherington have been appointed the other two members.

British Naval Losses

IT is with regret that in the week under review we have to announce some losses of British naval vessels. They include H.M. destroyer "Imogen," one of the ships of the "Intrepid" class, completed in 1937 by Hawthorn, Leslie, and the destroyer H.M.S. "Brazen," built by Palmers, in the 1928 "Beagle" class. The "Imogen" was lost as the result of a collision in a dense fog, while the "Brazen" was sunk while being towed into port following damage sustained in an air attack. Both ships were of the 1350-ton displacement type, having a length of about 312ft. between perpendiculars, about 32ft. beam and 8ft. 6in. mean draught. The armament comprised four 4·7in. guns, six smaller guns and torpedo tubes. The propelling machinery of both ships was of the Parsons geared turbine type, taking steam from three Admiralty three-drum pattern oil-fired boilers. The designed output was about 34,000 S.H.P. on twin-screw shafts, corresponding to a speed of 35 knots. The Admiralty also announced on Sunday, July 21st, that H.M. submarine "Salmon" was then considerably overdue and must be presumed lost. The "Salmon" was constructed at Birkenhead by Cammell Laird and Co., Ltd., and was one of seven ships of the "Shark" class, an improved "Swordfish" design. She was completed in 1935. Three other losses are the trawlers "Campina," "Rinovia" and "Crestflower," which sustained damage in mine and air attacks and subsequently sank. The loss is also announced on June 10th, following an air attack off the coast of Norway, of the naval auxiliary H.M.S. "Vandyck." In pre-war days she was well known as a Lamport Holt Line cruising liner, and was built and engined by Workman, Clark and Co., Ltd., at Belfast in 1921. About seven years ago she was refitted as a cruising liner and made many trips to the Atlantic islands and the African coast. With the losses we mention above the total number of naval ships lost since the outbreak of war is 117, of which more than half are minesweepers and trawlers. The "Salmon" is the eleventh submarine lost, which figure may be compared with the seventy or more lost by Germany and fifteen lost by Italy. With the loss of the "Brazen" the total number of destroyers sunk is now twenty-seven. At the outbreak of war we had, either already on the stocks or about to be laid down, forty new destroyers, and four "Tribal" class vessels were on trial. In addition, we took over eight destroyers which were under construction in British yards for Brazil.

Physical Problems in Industry

IN order to assist professional men who, in the present emergency, find themselves presented with technical problems in applied physics of which they do not happen to have had previous first-hand experience, it has been decided to extend the facilities of the Institute of Physics' Panel of Consultants. Through this medium inquirers are put into touch with those physicists most likely to be able to offer immediate practical suggestions in any particular case. In the first instance the contact is quite informal; subsequent arrangements are a matter for private agreement between those concerned. The subjects which can be dealt with cover all branches of physics, both pure and applied, including, for example, physical measurements and testing, the design and supply of scientific instruments for special purposes, and the control of processes by physical means. By acting as a clearing house in this way and supplementing existing official and unofficial organisations it is hoped to help in the national effort by directing attention to existing solutions of difficulties which, while appearing to be new problems, are often already well known in other fields. A typical example will serve to illustrate this point. A recent inquiry related to possible means of measuring the flow of certain animal secretions having complex physical properties, which prevented the use of more usual methods. It happens that certain printing inks have somewhat similar properties, and an informal introduction to a physicist in that industry has proved of great assistance. Inquiries about this scheme should be addressed to the Secretary of the Institute of Physics at the University, Reading, Berks.

The Mirrlees Watson Centenary

AT the recent annual meeting of Mirrlees, Bickerton and Day, Ltd., Mr. Charles Day made reference to the approaching centenary of the associated firm, The Mirrlees Watson Company, Ltd., which occurs this year, and said that the plans for its appropriate celebration would have to be postponed on account of the war. Some record of the engineering partnership formed in 1840, which during the past one hundred years has had a very active development in Glasgow and has taken a foremost part in the cane sugar producing industry of the world, may fittingly be given in these columns. By supplying machinery and men to the industry the firm of Mirrlees Watson has contributed greatly to the reputation of Glasgow as the world centre for the manufacture of cane sugar machinery. The firm had its beginning in 1840, when a partnership was formed by the three brothers, Peter, William and Andrew McOnie, the firm being styled P. and W. McOnie. In 1848 Mr. J. B. Mirrlees became a partner, and the title of the firm was altered to McOnie and Mirrlees, the name Mirrlees remaining in the firm since that time. In 1858 Mr. William Tait became a partner and the name was again changed to Mirrlees and Tait. In 1868, when Mr. Renny Watson joined the firm—later Sir W. Renny Watson—the title of the firm was altered to Mirrlees, Tait and Watson, which was retained until 1882. In that year Mr. R. A. Robertson and Mr. J. G. Hudson joined the firm, which was then styled Mirrlees Watson and Co. In 1889, with the taking up of the manufacturing rights for the Yaryan evaporator, the company was reconstructed under the name of Mirrlees, Watson and Yaryan, Ltd., and ten years later it took its present name, The Mirrlees Watson Company, Ltd. In 1900 Mr. Charles Day was appointed manager of the company, and under his direction rapid progress was made with the manufacture of the Diesel oil engine. By 1907 it was found that a new works would be necessary in order to deal with this new product, and a new company, Mirrlees, Bickerton and Day, was formed. Works were built at Hazel Grove, Stockport, and Mr. Charles Day became the managing director of both companies, which were amalgamated in 1926.

Automatic Train Control

No. III

(*Continued from page 38, July 19th*)

IN continuing this analysis of A.T.C. systems, the railways on the Continent of Europe come next for consideration. Nowhere is there to be found an exact parallel of British operating conditions. The position in the different countries offers some striking contrasts, but since the railways are almost everywhere State-owned, in general one does not meet within one country the divergences in practice to be seen in Great Britain. France, however, is a notable exception in this respect, though it was only from the beginning of the year 1939 that her railways were merged into one national concern. Prior to the outbreak of war very fast running was made over certain routes in France, Belgium, Italy, and Germany, the most noteworthy runs being scheduled at higher start-to-stop speeds than anything regularly run in this country. Some of these services were operated with lightweight railcars, which, so far as A.T.C. is concerned, constitute a problem in themselves.

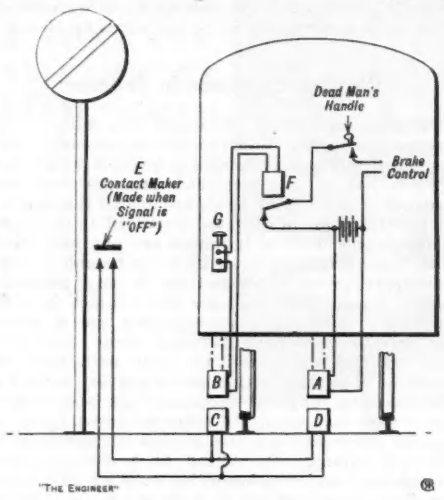

FIG. 17—SWISS FEDERAL RAILWAYS STANDARD A.T.C. LAY-OUT

In various parts of the Continent examples are to be found of all the British methods of pick-up from the track equipment to the locomotive, contact ramps in France and Belgium, inductive systems in Switzerland, Italy, Germany and also in France, and a mechanical tripping gear, though in this case elevated, is to be seen in the Kofler apparatus used experimentally in Poland and Jugoslavia. An examination of all these various systems reveals an almost universal acceptance of the principle of applying control and giving cab signals, based upon the indication displayed by the distant signals. In Germany the system is greatly elaborated to include a number of checks upon the driver's correct discharge of his duties, though no cab signals are included. There, insistence is made upon the observance of the line side signals, while to ensure that a man is alert and does not fall idly into the habit of pressing buttons in order to avert an automatic brake application, the cancelling action is only effective within a brief time from passing the adverse signal.

The nearest approach to the accepted British principle, discussed in the second article of this series, is to be found in Switzerland. The only important difference from the Hudd and Great Western systems is that no cab signal at all is given when the distant signal is in the clear position. Fig. 17 shows the principle adopted as standard by the Swiss Federal Railways. One of its most interesting features is that no power supply is required for the line side equipment—an inversion of the customary arrangements in this country, where efforts have been made to eliminate any need for electrical supply on the locomotives. In Switzerland, however, the standard lighting set is already available on the electric locomotives concerned. These locomotives are fitted with a "dead-man's handle," as used on the London Transport multiple unit electric trains, and the A.T.C. equipment is arranged to cause an effect, on passing an adverse distant signal, identical with that produced when the dead-man's handle is released.

Referring to Fig. 17, A and B are inductors mounted on the locomotive, and of these, inductor A is permanently connected to the source of electric power supply. Inductors C and D are mounted on the track, exactly in line with the distant signal; they are connected as shown, and both are also connected to a contact maker E, actuated by the movement of the signal. If the signal is in the warning position, the track inductor circuit is broken at E. The passage of a locomotive causes an induced current in D. This, in turn, is relayed back to the other part of the locomotive circuit by induction between units C and B, and the flowing of this current energises the relay F and breaks the dead-man's handle circuit, ringing a bell at the same time. By pressing the vigilance button G, however, the driver can prevent the automatic application of the brakes. When the distant signal is at clear, inductor C is short-circuited by the contact maker E, and consequently no current is induced in B. A further point of divergence from the British systems will be apparent from this description. The train control effect depends entirely upon the position of the signal itself, whereas in this country it is the position of the signal lever in the box that determines the nature of the control.

The success of this system and its adoption as standard by the Swiss Federal Railways led to its being developed and adapted to French operating conditions by the Société Parisienne Metrum. In its thus modified form it has been subjected to a trial on the Alsace-Lorraine section of the Eastern Region, French National Railways. On this particular section the distant signals display any one of three indications—the signalling system being in general based on German principles.

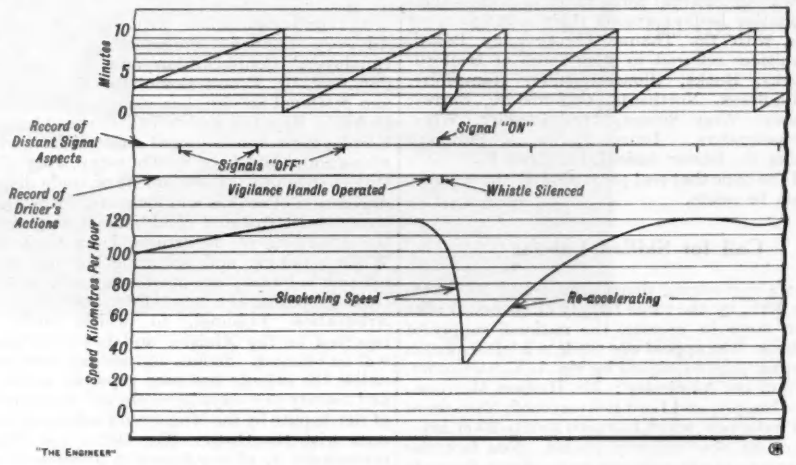

FIG. 19—FRENCH LOCOMOTIVE PERFORMANCE CHART

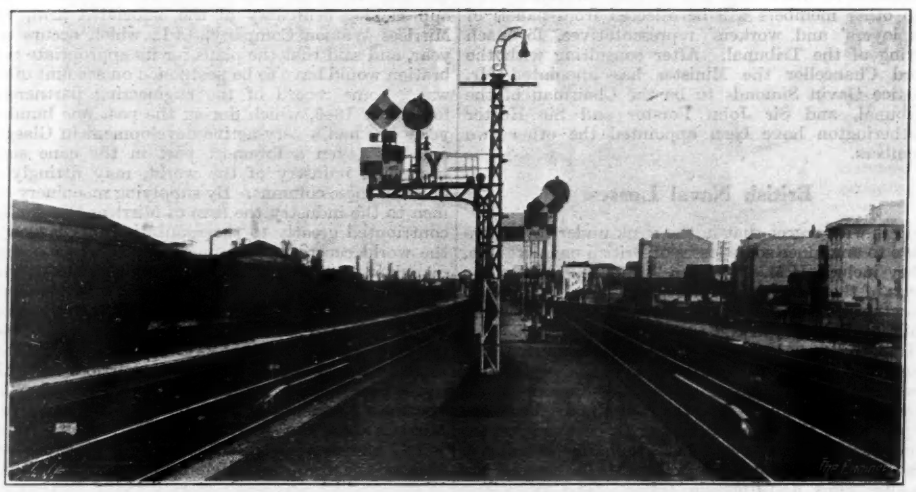

FIG. 18—"CROCODILES" ABREAST OF DISTANT SIGNALS

These indications are "Proceed," "Caution," and "Attention," the latter having no counterpart in British practice, and signifying that reduced speed is necessary when passing the home signal. To reproduce these indications in the form of cab signals and train control effects, three inductors are needed on both the track and the locomotive. Visual signals are illuminated in the cab according to the indication displayed by the wayside signal, and these are supplemented by a hooter. The Metrum system is, indeed, the only intermittent form of A.T.C., in which both visual and audible cab signals are given for every aspect of the wayside signals. To avoid an automatic brake appliion in the case of the "Caution" or "Attention" aspect, the driver must press the vigilance button before reaching the wayside signal; after passing, he must press again to silence the hooter, which in these circumstances sounds continuously after the inductors are passed over. A short blast is given on passing a distant signal showing "Proceed."

The Metrum system, however, stands out quite apart from the general line of development in France. It is the only instance of automatic train control in the truest sense of the term, for in the extensive installations in other parts of the country cab signalling only is used. What is known as the "crocodile" apparatus is now in general use on the main lines. The track equipment takes the form of a ramp or "crocodile," with which a brush on the locomotive makes contact and picks up current used for the giving of cab signals. Indication is given at the distant signals only, and a whistle sounded in the cab when the wayside signal is in the danger position. No cab signal at all is given in the clear position, since then the ramp is not alive, and no current is picked up. Fig. 18 shows "crocodiles" installed abreast of distant signals.

Realising that the open-circuit principle on which this system is based may have dangerous results in case of failure to make contact, French engineers have gone to considerable lengths to make the pick-up arrangements as reliable as possible under all conditions of weather. Various different forms of ramp had been introduced on the former independent railways. A widely used form of anti-frost ramp includes an oil reservoir, in the top of which are a series of holes; in each of

these holes is a wick. The oil feeds up from the reservoir and spreads over the entire upper surface, and so prevents frost. In other arrangements purely mechanical aids to better contact are employed, such as a ramp with a slotted surface on which a passing collector brush has a strong rubbing action on a large number of edges, thus tending to keep the contact faces clean and to sweep away any formation of ice. These devices, interesting as they are, can only be regarded as palliatives, and not in any way counteracting what it cannot be denied is a fundamental weakness in the system as a whole.

Quite apart from the design of the ramps the and ramp. In addition to its widespread use in France, this system of audible cab signalling is used in Belgium.

The latest development in cab signalling on the French railways has been the installation of continuous indication colour-light signals on the Etat main line between Caen and Cherbourg. This is an adaptation, to suit French signalling, of the most recent American practice, and it is intended to hold over detailed description of the working of this system until dealing with the latest developments in the U.S.A. It may be mentioned here, however, that the section of line is track circuited throughout, and that the

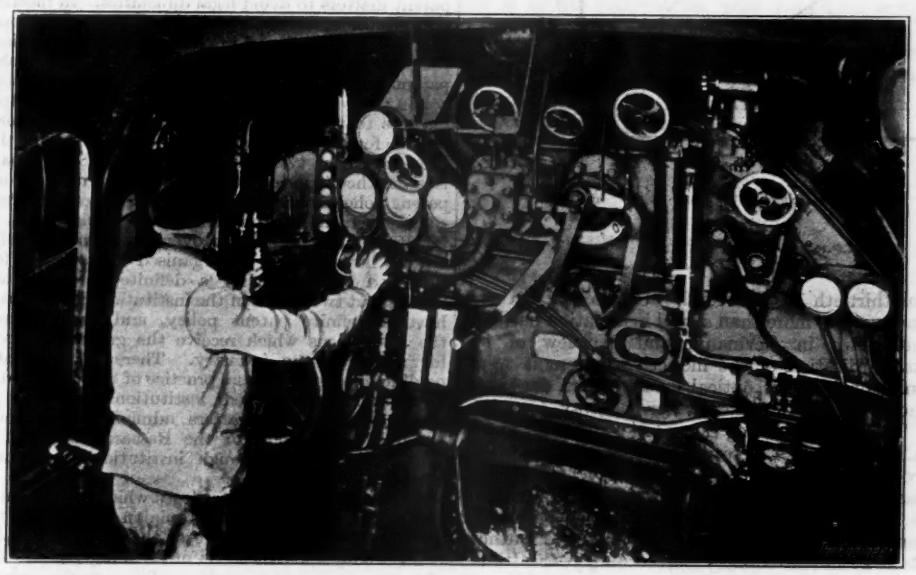

FIG. 20—CONTINUOUS INDICATION CAB SIGNAL ON FRENCH LOCOMOTIVE

most elaborate arrangements are in force for checking and recording the operation of the cab signals, and also for the checking of the driver's work. The Flaman speed recorder is fitted to the vast majority of French locomotives, and on the speed chart produced by this appliance a record is also made of the aspect displayed by every warning signal, and of the action taken by the driver. Fig. 19 shows a portion of one such chart. The uppermost graph is a time-distance curve, and the lowest a speed-distance curve. Between the two are the records of signal aspects and of the driver's work. The pen making the former traces a horizontal line across the chart until a crocodile is passed

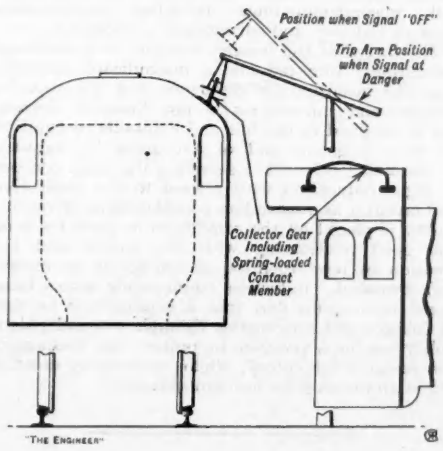
Position when Signal "OFF"
Trip Arm Position when Signal at Danger
Collector Gear Including Spring-loaded Contact Member
"THE ENGINEER"

FIG. 21—KOFLER A.T.C. SYSTEM

over; then a mark is made above or below the line, according to whether the signal is showing "Caution" or "All Clear" respectively. The lower horizontal line records the action taken by the driver on receiving the caution signal; two marks below the line are made in rapid succession, the first noting the operation of the vigilance handle and the second the silencing of the whistle. Examination of these charts every day quickly reveals any irregularities in the working of the system and in the work of individual engine crews. A scheme for checking the working of the crocodile is now being tried out in France. By means of a permanent magnet inductor in the track and suitable additional gear on the locomotive, the driver is notified if the danger signal is for any reason not given through the contact between collector brush wayside signals are long-range colour-lights. Fig. 20 shows a cab view of one of the express locomotives equipped, and it will be noted that the visual signal, just in front of the driver, apparently has five aspects. There are, first of all the three familiar colours—green for proceed, yellow for caution, and red, shown when a train is running in an occupied section under "stop and proceed" rules. Then a double yellow is given where a sharp junction turn-out has to be negotiated, and an illuminated yellow letter P, in conjunction with a green, is displayed in the cab when the next signal ahead is showing the caution aspect. This latter cab signal acts as a preliminary warning and it is unique. The Caen–Cherbourg installation, though as yet in service for a comparatively short time, has proved a great success, but whether or not, under State ownership of the railways, it will eventually be extended to supersede the "crocodile" apparatus remains to be seen.

In striking contrast to this elaborate system is an almost entirely mechanical apparatus installed experimentally some months prior to the outbreak of war on the Polish State Railways. This is a development of the Kofler all-mechanical A.T.C. system, first used on light electric railways where speeds are not ordinarily high. It constitutes in many ways a revival of one of the earliest forms of A.T.C. ever devised, and used in the U.S.A. as long ago as 1889. It consists of a striking member working in conjunction with the arm of the wayside signal, on the same principle as the automatic train stops on the Underground railways of London. Owing to the severe climatic conditions experienced in Central Europe a train stop mounted in the 6ft. way is not considered a practical proposition, and the Kofler apparatus is arranged to operate in conjunction with an element on the roof of the railcar, or locomotive cab; this element includes a contact-making member which, when struck by the train stop, is moved so as to apply the brakes. Fig. 21 shows in diagrammatic form a trip arm mounted alongside a distant signal as used on the Polish State Railways, and the apparatus mounted on the roof of the locomotive cab.

As originally designed and installed on the Isar Valley Railway, near Munich, no brake control was included; when an adverse signal was passed a whistle was sounded. A subsequent installation, on the Cologne–Bonn electric railway, included brake control, and for this purpose the trip arm had naturally to be located some distance in rear of the stop signal, instead of on the actual signal mast as on the Isar Valley line. Both these German examples are, however, on purely local lines, and when the apparatus was selected for trial on a main line of the Polish State Railways colour-light cab signals and other refinements were added. Normally, a green light is displayed in the cab, but when the locomotive gear is struck by the trip arm of a distant signal at "caution" the cab signal changes to red and a hooter begins to sound. If the driver duly observes the warning and begins to apply his brake the hooter is silenced, and the cab signal is restored to its normal aspect; if he does not, a partial application of the brake is made, and if still no action is taken by the man a full application follows. This system is particularly interesting in that with ordinary working no plunger needs to be operated to cancel the automatic brake application; the cancelling effect is produced by the operation of the ordinary brake valve. This modified form of the Kofler apparatus, as used in Poland, has also been installed on at least one section of the State Railway of Jugoslavia.

Brief reference has already been made to the system of inductive A.T.C. now standardised on the German State Railway. Here a cancellable brake application, on passing the distant signal, is not considered enough, and as a further check upon the driver's action there are included speed controls and an irrevocable brake application at the home signal. A single magnet is suspended from the locomotive. This magnet has three different resonant windings, tuned to frequencies of 500, 1000, and 2000 cycles, and energised from a turbo-generator set mounted on the boiler. As shown in the track lay-out diagram, Fig. 22, these correspond to the absolute stop, distant signals, and speed controls, respectively. When the signals are at danger, and the line-side magnets are energised, reaction is caused at the appropriate time between the corresponding resonant circuits on the locomotive and the track, and the resulting momentary reduction of current in the locomotive circuit causes, by relay action, a suitable train-control effect.

In actual practice a driver must duly observe the distant signal, and if it is showing "caution" he must press the vigilance button within five seconds of passing that signal. After a further space of time from passing the signal he must have reduced speed to a predetermined figure. Failure to act upon either of these instructions results in an automatic application of the brake. At the stop signal a dead stand is compelled in

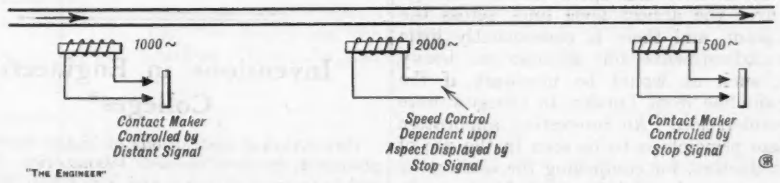

FIG. 22—GERMAN A.T.C. INCLUDING SPEED CONTROL

the event of an overrun. As previously mentioned there are no audible signals in conjunction with this scheme. An electric hooter is provided, but this is only sounded when the brakes are applied independently of the driver. As in France, great care is taken to record the working of the A.T.C. apparatus; in addition to the speed of the train throughout the journey, all the various train-control effects are duly registered on the chart, together with the driver's action—pressing the vigilance button, for example—in each particular instance.

An outstanding feature of German express train services operating before the outbreak of war was the number of ultra-high-speed railcar units maintaining schedules that demanded continuous running at 100 m.p.h. With such units the principles of speed control, as previously stated, naturally require very careful working out in actual practice. As with ordinary express passenger trains, the driver is given five seconds from passing an adverse distant signal in which

to operate the vigilance handle, but the subsequent speed control is necessarily different. The first check upon the speed results from the passing of an adverse distant signal, and on level road the speed of an ordinary express running at 75 m.p.h. must be reduced to 56 m.p.h. within twenty-two seconds of passing the signal; with a railcar running at 100 m.p.h. the speed must be reduced to 69 m.p.h. within fifteen seconds. Failure to comply with these regulations results in an emergency application of the brakes.

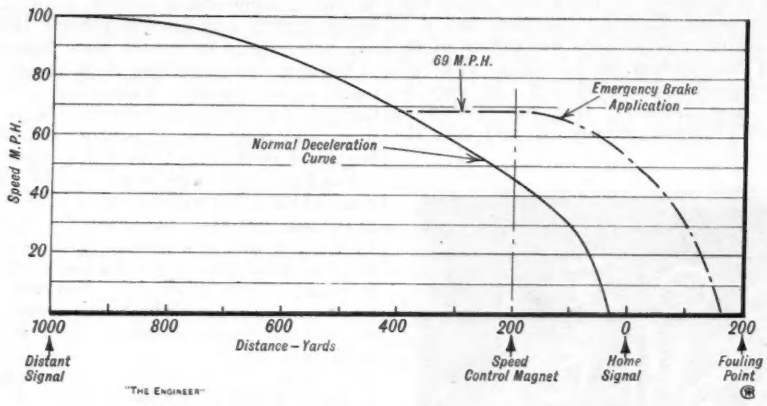

FIG. 23—DECELERATION OF 100 M.P.H. RAILCAR

Having observed these reductions there is nothing to prevent an engineman driving on at the lower speed; to safeguard against the possible effects of such an action a further speed control is introduced, based this time upon the indication displayed by the home signal. Fig. 23 shows, in graphical form, the time-speed curve corresponding to a brake application following the passing of an adverse distant signal. The fouling point is shown at 200 yards beyond the home signal. From this diagram it will be seen that a railcar travelling at 100 m.p.h. will be brought to rest some 30 yards short of the home signal, under the uniform deceleration caused by a service application of the brakes immediately on passing the distant signal. A further speed curve is added to show the effect, should a driver continue to run at 69 m.p.h., after the prescribed fifteen seconds has elapsed. It is then that the speed-control inductor, based on the home signal indication, takes effect. This inductor is placed about 200 yards in advance of the home signal, and if the speed is in excess of the figure corresponding to the normal deceleration curve an emergency application is made, which the driver is powerless to cancel. As will be seen, this action does not prevent an overrun, but the train is stopped a little distance short of the fouling point.

The physical nature of many of the routes now equipped has undoubtedly assisted, not only in the establishment of a standardised system, but also in a largely standard practical application. Much of the German high-speed railway mileage is made over the almost level lines across the northern plain, and there is consequently little need for adjustments on account of heavy gradients, such as would be necessary if the L.M.S. main line from London to Glasgow were under consideration. An interesting application of the same principle is to be seen in the use of portable inductors, for compelling the observance of temporary speed restrictions, as, for example, when relaying is in progress. This practice could, of course, be carried out equally well with the Hudd system in this country, though only to the extent of giving the driver an audible warning that he was nearing a length of restricted speed.

Concurrently with the development and eventual standardisation of the inductive system on the German State Railway, other A.T.C. devices operating on very different principles, have been tried out in that country. Reference has already been made to the Kofler mechanical system, and mention must be made, too, of a method of optical train control, which, so it is claimed, is capable of exercising control to suit any conceivable requirement of ordinary traffic operation. The receiver on the locomotive in this case is a selenium cell, which has the property of altering its electrical state under the influence of light. The indications of the wayside signals are transmitted to this receiver through the agency of a multi-plane mirror moving in conjunction with the semaphore arm of the signal; the source of light is on the locomotive itself. According to the position of the mirror "signals" of varying electrical strength are picked up by the selenium cell, and duly amplified for train-control purposes. The sensitive nature of the receiving apparatus may be gauged from the brief time during which the mirror is illuminated by the "searchlight" of a fast moving train; at 75 m.p.h. this is but one-thirtieth of a second. Up to the present, however, no more than a trial installation has been put down in Germany, and in view of the standardisation of the inductive system it seems unlikely that this optical arrangement, ingenious though it is, will make further headway.

The only remaining European country to install A.T.C. is Italy. Here present-day practice differs from that of every other country. Control is based on the distant signal, but at junctions it is now usual to employ "splitting" arms for route-indicating purposes, as on the Southern Railway in this country. Accordingly, the Italian train-control arrangements include audible cab signals to indicate the route to be taken. As in the Hudd system, no electric power supply is needed on the locomotive, all necessary control being effected by compressed air taken from the Westinghouse brake compressor plant. A number of track inductors are necessary, as on the Alsace-Lorraine lines, to give the various signals and control effects required.

Summing up modern A.T.C. practice on the Continent of Europe, one has to record nothing but wide divergences between one country and another, though certain of the State-owned railways —notably those of Switzerland and Germany— seem definitely to have made up their minds on the system to be universally adopted in their own territory. It is in France, perhaps, that the most interesting trends are to be seen, both in the continuous colour-light cab signals on the Cherbourg line, and in the recent experiments with inductive proving of the "crocodiles." Future developments will be watched with the greatest interest.

(To be continued)

Inventions in Engineering Colleges*

EDUCATIONAL institutions of higher learning have produced, in their research laboratories, discoveries and inventions of value and importance to industry and agriculture. Not until comparatively recent years, however, have colleges and universities realised that their technical research programmes would better serve mankind if commercial and public needs were strongly considered in their planning and if the co-operation of industry were available. In making the products of the laboratory available to society, colleges and universities have found that dedicating the findings of research to the public actually withholds these findings from use. Likewise, industry is very reluctant to invest in co-operative research unless patent rights are obtained for the results of research allowing adequate protection for the commercialisation of the new findings. For these reasons it has been found that educational institutions operating their research programmes under definite patent policies are in the best position to enhance technical progress.

Formal arrangements with staff members regarding patents usually apply to cases of research programmes financed entirely by the university, college, or institute, or by some outside agency or donor in connection with co-operative research programmes. Inventions not financed by educational institutions or by agencies co-operating with them are the property of the individual teacher or research specialist. Where research foundations have been established they are available for use by staff members in connection with their own inventions. Equitable sharing of ownership is decided upon in instances where others have a legal right to a share in the new finding. In co-operative research, even if it is financed entirely by industry, the resulting patents are assigned to the educational institution, which, in turn, usually shows special consideration to the donor in the matter of licensing. The securing and administering of patent rights is considered by the governing boards of many institutions to be outside of their jurisdiction, and, in State-supported colleges and universities, much caution must be taken in the handling of patent matters to avoid legal difficulties. In meeting this situation, seven of the thirty-nine educational institutions, questioned in the study, have organised research foundations for administering desirable patent policies, while one other is planning such action; three have entrusted the handling of patent matters to the Research Corporation of New York, and a fourth is considering the adoption of this procedure; in two other instances a State board is given the responsibility for patent administration; patent policies and problems in thirteen other educational institutions are under the jurisdiction of faculty committees and/or governing boards. Twelve schools have not as yet organised or have not felt the need of formulating a definite patent policy. Thus about two-thirds of the institutions investigated have a definite patent policy, and these include the institutions which receive the greatest support for research from industry. There is apparently no difference in the actual practice of State-supported and privately endowed institutions. Nearly as many have patent matters administered through research foundations, or the Research Corporation of New York, as through institutional governing boards.

Those universities and colleges which have definite patent policies are of the opinion that both the social and economic welfare of the public are being enhanced by their methods of handling patents and of encouraging creative activity of their staff members. Unexploitative commercialisation of patents is of definite value to the public. Earnings received from patents are used to reward the inventor and to support research.

The procedure of utilising the personnel and equipment of educational institutions in co-operative research with industry is sometimes looked upon with doubt and disapproval. Colleges and universities often are prejudiced against co-operative research because of the legal and administrative problems involved, precedent and policy of governing boards, and moral and ethical principles. On the other hand, industry is often sceptical of co-operative research on the grounds that educational institutions are too unbusinesslike, and too theoretical in their research activities. The initiative in bridging the gap between the two groups can be taken by colleges and universities in formulating and administering patent policies designed to remove the difficulties and misunderstandings retarding co-operation between industry and educational institutions.

The fact that the income accruing to educational institutions from patents is insignificant indicates that the incentive for discovery and invention in colleges and universities is not financial reward, but is involved in the fair and equitable recognition of creative genius and of aid given by industry to research. Scientific research is the main concern of higher education with reward to the institution and inventor as a secondary consideration. Inventive ability is placed on the same level as good teaching and good relationship with the public, and the creation of new scientific knowledge is recognised and rewarded. Industries co-operating with educational institutions find that a considerable number of colleges and universities through a sound patent policy are in a position to protect the findings of the research laboratory, while encouraging creative talent and reward for accomplishment.

* From an address to the American Association for the Advancement of Science, December, 1939, by A. A. Potter, Purdue University.

LARGE INDUSTRIAL CONVEYOR BRIDGE.—An industrial bridge nearly 1000ft. long, believed to be the largest of its type in the United States, has been completed and placed in operation at the Mansfield plant of the Westinghouse Electric and Manufacturing Company. The bridge houses three lines of conveyors for connecting the main Westinghouse plant and the company's vitreous enamel plant more than two city blocks away. The conveyors are used to carry range and refrigerator bodies and parts from the metal stamping department to the enamelling plant and back to the assembly departments. Entirely enclosed by metal siding and continuous windows on both sides, the bridge is 20ft. wide and 13ft. high at its highest point. It is 30ft. from the ground where it enters the third floor of the main plant. In addition to the three lines of conveyors, the bridge includes a 6ft. aisle for electric trucks and pedestrians. One conveyor is of the belt type and can run in either direction at a speed of 40ft. a minute. The other is an over-and-return overhead chain conveyor with suspended carrying baskets, with a variable speed ranging up to 30ft. per minute. The new bridge replaces a fleet of lorries which previously were used to carry parts between the two buildings.

Notes on Methods of Balancing

By K. R. HOPKIRK, M.A. (Cantab.)

No. II

(*Continued from page 39, July 19th*)

Practical Calculations

THE arithmetical labour involved in solving the equations can be reduced to a few simple slide rule calculations. Means for the evaluation of the vectors $\bar{c}$, $\bar{d}$, $\bar{e}$, and $\bar{f}$ for the three methods of solution already given are first described.

Method 1.—A simple geometrical process for finding the vectors $\bar{c}$, $\bar{d}$, $\bar{e}$, or $\bar{f}$ is illustrated in Fig. 3. A complete circular transparent protractor is required, scaled round the edge in degrees. Three radii should be marked on it corresponding

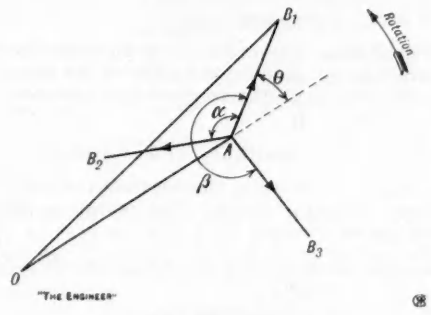

FIG. 2 (REPRODUCED)

to the vectors A B_1, A B_2, and A B_3 of Fig. 2, and preferably 120 deg. apart. These radii should be scaled commencing at zero at the centre, and marked 1, 2, and 3 corresponding to B_1, B_2, B_3. With a common centre 0, three circles are drawn, their radii being respectively u_1, u_2, and u_3, as measured on the radial scale of the protractor. A point A is marked on a radius of these circles such that O A$=u$. The protractor is placed with its centre at A and rotated until the lengths intercepted along the radii 1, 2, and 3 by the circles of radius u_1, u_2, and u_3 respectively are are all equal. The points of intersection of the radii with their respective circles correspond to the points B_1, B_2, and B_3 of Fig. 2. The angle between O A and A B_1 can be read off directly on the protractor, and the length A B_1 is read off on the radial scale.

If the measurements of u, u_1, &c., are not exact, it may not be possible to adjust the protractor to make all the intercepts exactly equal. A near approximation must then be made, and for this purpose the centre may be shifted slightly from A.

Alternatively, the calculation can be made from the curves of Fig. 4. The three measurements u_1, u_2, and u_3 must be made with the weight in positions 120 deg. apart, and will in general all be different. In Fig. 4, k_1 and k_2 are ratios of the measurements as specified in the table below.

The curves give the values of k_3 and θ for the point (k_1, k_2). Thus, if k_1=0·6 and k_2=1·5, k_3 will be 0·53 and θ will be 36 deg. The value of k_3 is the ratio of the trial weight to weight required, and θ gives the position at which it is to be located according to the table. A positive sign in the last column indicates a direction leading

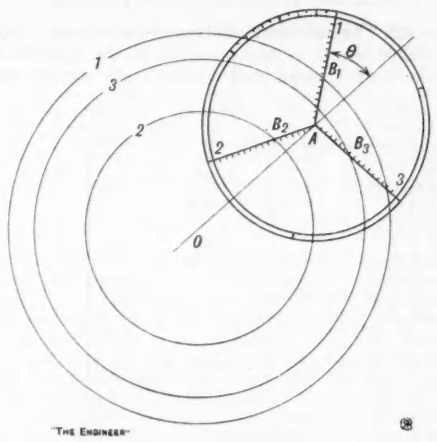

FIG. 3

on the reference direction, and a negative sign a lagging direction :

Order of smallness of measurements.	k_1.	k_2.	Angle of vector $\bar{c}$, $\bar{d}$, $\bar{e}$, or $\bar{f}$.
1 2 3	$\frac{u_1}{u_2}$	$\frac{u_3}{u}$	θ
1 3 2	$\frac{u_1}{u_3}$	$\frac{u_2}{u}$	$-\theta$
2 3 1	$\frac{u_2}{u_3}$	$\frac{u_1}{u}$	θ+120 deg.
2 1 3	$\frac{u_2}{u_1}$	$\frac{u_3}{u}$	120 deg.$-\theta$
3 1 2	$\frac{u_3}{u_1}$	$\frac{u_2}{u}$ ...	$-$(120 deg. $-\theta$)
3 2 1	$\frac{u_3}{u_2}$	$\frac{u_1}{u}$ ...	$-$(120 deg. $+\theta$)

In the first column of the table, the figures 2, 1, 3, for instance, indicate that the smallest measurement with the trial weight occurs for position 2, and the largest measurement for position 3.

If two measurements are equal and less than the third, either of the two equal measurements may be taken as the smallest. Thus, if u_2 and u_3 are equal and less than u_1, the order may be taken as 3, 2, 1, or 2, 3, 1. Similarly, if two are equal and greater than the third, as u_3 and u_2 equal and greater than u_1, the order may be either 1, 2, 3, or 1, 3, 2. The range covered by the curves corresponds to a trial weight varying from 10 to 100 per cent. of the weight required.

Method 2.—The geometry of the triangle O A B_1 is self-evident, the two sides O A and O B_1, and the angular displacement A O B_1 of the vibration having been measured. The ratio of trial weight to weight required is the ratio of A B_1 to O A, and the angle of the vector is B_1 A O.

An alternative method of calculation without geometry is as follows. The vector equation of the vibration triangle A O B_1 is

$$\bar{x}=\bar{u}_1-\bar{u},$$

where $\bar{u}$, $\bar{u}_1$, and $\bar{x}$ are respectively O A, O B_1, and A B_1 in Fig. 2, so that

$$-\bar{u}=\bar{x}\,.\,\frac{1}{1-\frac{\bar{u}_1}{\bar{u}}} \quad \text{if } \bar{u} \text{ is longer than } \bar{u}_1,$$

or

$$-\bar{u}=-\bar{x}\,.\,\frac{\bar{u}}{\bar{u}_1}\,.\left(\frac{1}{1-\frac{\bar{u}}{\bar{u}_1}}\right) \text{if } \bar{u}_1 \text{ is longer than } \bar{u}.$$

The vector $-\bar{u}$ represents the vector $\bar{c}$, $\bar{d}$, $\bar{e}$, or $\bar{f}$, according to the particular set of measurements used.

The calculation of these expressions is described

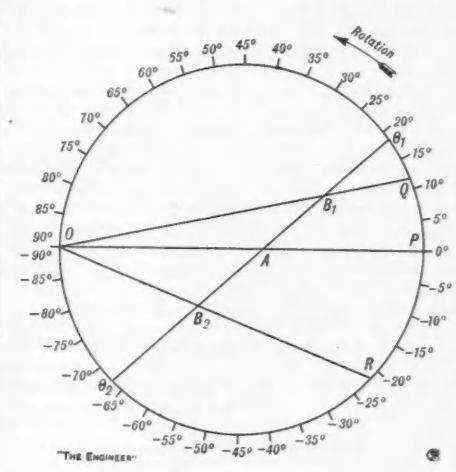

FIG. 5

later, being effected in the same manner as the calculation of $\bar{a}$ and $\bar{b}$.

Method 3.—Since only two positions of the trial weight in each plane are required to determine $\bar{c}$, $\bar{d}$, $\bar{e}$, and $\bar{f}$, the obvious arrangement is to choose two positions 180 deg. apart. The calculation of $\bar{c}$, &c., is illustrated in Fig. 5. A standard chart is constructed by drawing the circle O Q P R on squared paper and scaling in degrees as shown. Note that the angular scale is measured from the point O on the diameter O P. Let the angle P O Q be the angular change in vibration produced by adding the trial weight in position 1. In the example illustrated this is 12 deg. leading on the position found without the trial weight, and can be measured by marking the shaft, or by suitable instruments.

Let the angle P O R be the angular change of vibration produced by adding the trial weight in position 2. In the example it is 22 deg. lagging.

Take any two lines equally spaced above and below O P, and parallel to O P, and let the inter-

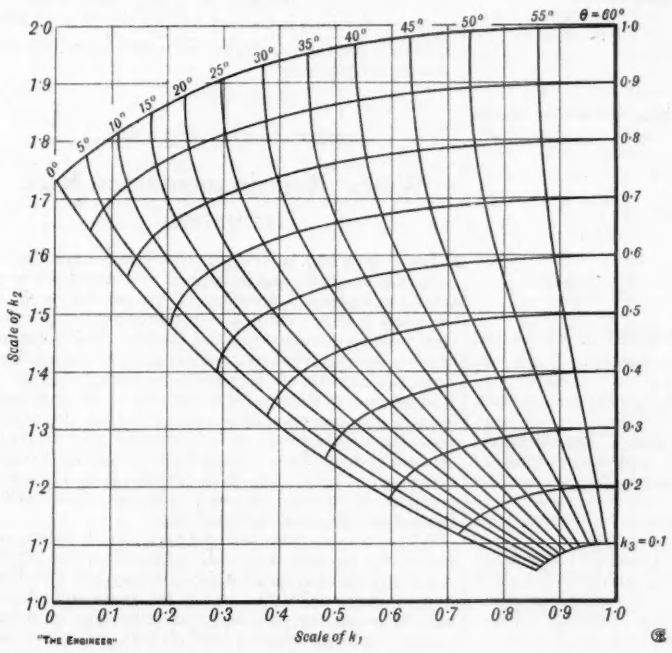

FIG. 4

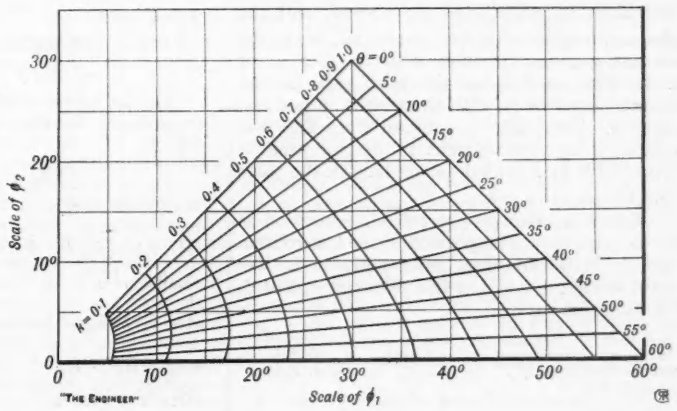

FIG. 6

sections of O Q and O R with these lines respectively be B_1 and B_2. Join B_1 and B_2 and let this line cut the circle at angular position θ_1 on the shorter arc O Q and at θ_2 on the shorter arc O R, and let it intersect O P at A.

In the figure, O A represents $-\bar{c}$, and A B_1 and A B_2 the trial weight in positions 1 and 2 respectively. The ratio of weight required to trial weight is therefore the ratio of O A to A B_1, and can be found by scaling.

The angle B_1 A O—that is, the angle of $\bar{c}$ taking position 1 as the reference position, is as follows :

If position 1 gives a leading angle, position 2 will give a lagging angle, and the angle of $\bar{c}$ is

$$90 \text{ deg.} - (\theta_1 + \theta_2).$$

In the example, this gives the angle of $\bar{c}$ equal to 90 deg.$-$(18·5 deg.$-$67 deg.)—that is, 138·5 deg.

If position 1 gives a lagging angle, the angle of $\bar{c}$ is

$$-(90 \text{ deg.} + \theta_1 + \theta_2).$$

If by accident the reference position 1 is so chosen that the line B_1 B_2 has only a small angular displacement from the line O P, the calculation of the ratio of A B_1 to A O will tend to become very inaccurate. A further method is therefore given, in which three positions of the trial weight 120 deg. apart are used in each plane. Two out of the three measurements are chosen, and the angles and lengths of $\bar{c}$, &c., are found, using the table below in conjunction with the curves of Fig. 6. The numbers in the table refer to the angular measurements with the weight in position 1, 2, or 3. The value of k found from Fig. 6 is the ratio of the trial weight to weight required and the value of θ is used as specified in the table to find the angle of $\bar{c}$, &c.

Position 1 is taken as the reference position in the rotor, and the angle specified in the last column of the table is measured from position 1. No account of sign is taken in the values of ϕ_1 and ϕ_2 when using the curves :

Nature of angular measurements.	Measurement used for ϕ_1.	Measurement used for ϕ_2.	Angle of vector $\bar{c}$, $\bar{d}$, $\bar{e}$, or $\bar{f}$.
1 and 2 leading, 3 lagging ...	3 ...	1 ...	120 deg.$+\theta$
2 and 3 leading, 1 lagging ...	1 ...	2 ...	-120 deg.$+\theta$
3 and 1 leading, 2 lagging ...	2 ...	3 ...	θ
1 and 2 lagging, 3 leading ...	3 ...	2 ...	$-\theta$
2 and 3 lagging, 1 leading ...	1 ...	3 ...	120 deg.$-\theta$
3 and 2 lagging, 2 leading ...	2 ...	1 ...	-120 deg.$-\theta$

Calculation of $\bar{a}$ and $\bar{b}$.—The four vectors $\bar{c}$, $\bar{d}$, $\bar{e}$, and $\bar{f}$, calculated by one of the methods described above, are all specified by their lengths and angular positions with reference to position 1 in the rotor. Each vector can therefore be written in the form (R, θ), R being the length and θ the angle.

The operations of multiplication, division, and subtraction are performed according to the following rules :—

(1) The product of two vectors is a vector whose length is the product of the lengths of the two vectors and whose angle is the algebraic sum of the angles of the two vectors.

Thus,

$$(R_1, \theta_1) \cdot (R_2, \theta_2) = (R_1 \cdot R_2, \theta_1 + \theta_2).$$

As an example,

$$(5, 25 \text{ deg.})\,(3, -47 \text{ deg.}) = (15, -22 \text{ deg.})$$

and

$$(5, 25 \text{ deg.})\,(3, 47 \text{ deg.}) = (15, 72 \text{ deg.}).$$

(2) The quotient of two vectors is a vector whose length is the quotient of the lengths of the two vectors and whose angle equals the angle of the numerator minus the angle of the denominator.

Thus,

$$\frac{(R_1, \theta_1)}{(R_2, \theta_2)} = \left(\frac{R_1}{R_2}, \theta_1 - \theta_2\right).$$

As an example,

$$\frac{(5, 25 \text{ deg.})}{(3, 47 \text{ deg.})} = (1{\cdot}67, -22 \text{ deg.}).$$

(3) The vectors may be added or subtracted graphically in the usual manner. Thus, in Fig. 2,

$$O\,B_1 = O\,A + A\,B_1.$$

By means of the curves of Fig. 7, the graphical method may be avoided and the value of $(R_1, \theta_1) - (R_2, \theta_2)$ can be found as follows :—

If $R_1 > R_2$

$$(R_1, \theta_1) - (R_2, \theta_2) = (R_1, \theta_1) \cdot \left[1 - \left(\frac{R_2}{R_1}, \theta_2 - \theta_1\right)\right],$$

and if $R_2 > R_1$,

$$(R_1, \theta_1) - (R_2, \theta_2) = -(R_2, \theta_2) \cdot \left[1 - \left(\frac{R_1}{R_2}, \theta_1 - \theta_2\right)\right].$$

In either case the expression on the right-hand side in the square brackets is of the form $1-(k, \theta)$, where $k < 1$.

Let $1-(k, \theta) = (R, \phi)$.

In Fig. 7 find the point corresponding to k on the scale of abscissæ and the curve whose value is θ. The scale of ordinates gives the value of R. Now find the point corresponding to this value of R on the scale of abscissæ, and the value of k on the scale of ordinates. The curve on which this point lies gives the value of ϕ. The sign of the angle ϕ will be opposite to the sign of θ, the curves taking no account of signs. The value of $(R_1\theta_1) - (R_2\theta_2)$ is thus

$$(R \cdot R_1, \theta_1 + \phi), \text{ or } -(R \cdot R_2, \theta_2 + \phi),$$

as the case may be, the angle ϕ being given its appropriate sign.

It should be noted that

$$-(R, \phi) = (R, \phi \pm 180 \text{ deg.}).$$

As an example

$$(3, 25 \text{ deg.}) - (5, 72 \text{ deg.}) = -(5, 72 \text{ deg.}) \cdot [1 - (0{\cdot}6, -47 \text{ deg.})].$$

Thus $k = 0{\cdot}6$ and $\theta = -47$ deg. From the curves, R = 0·735 and $\phi = +36{\cdot}5$ deg., so that

$$\begin{aligned}(3, 25 \text{ deg.}) - (5, 72 \text{ deg.}) &= -(5, 72 \text{ deg.})\,(0{\cdot}735, 36{\cdot}5 \text{ deg.}) \\ &= -(3{\cdot}675, 108{\cdot}5 \text{ deg.}) \\ &= (3{\cdot}675, -71{\cdot}5 \text{ deg.})\end{aligned}$$

The addition of two vectors may be changed to a subtraction by changing the angle of the shorter vector by 180 deg. and then proceeding as above.

Thus, if $R_2 > R_1$

$$(R_1, \theta_1) + (R_2, \theta_2) = (R_2, \theta_2) - (R_1, \theta_1 \pm 180 \text{ deg.}).$$

Using the above rules, the calculation of $\bar{a}$ and $\bar{b}$ becomes a simple matter. The process is illustrated by the example which follows.

Let $\bar{c} = (3, 37 \text{ deg.})$, $\bar{d} = (4, 78 \text{ deg.})$, $\bar{e} = (9, 25)$, $\bar{f} = (8, 60 \text{ deg.})$

$$\bar{a} = \frac{\bar{c}\,\bar{e}\,(\bar{f} - \bar{d})}{\bar{d}\,\bar{e} - \bar{c}\,\bar{f}}$$

$$= \frac{(3, 37 \text{ deg.})\,(9, 25 \text{ deg.})\,[(8, 60 \text{ deg.}) - 4, 78 \text{ deg.})]}{(4, 78 \text{ deg.})\,(9, 25 \text{ deg.}) - (3, 37 \text{ deg.})\,(8, 60 \text{ deg.})}$$

$$= \frac{(27, 62 \text{ deg.})\,(8, 60 \text{deg.})\,[1 - (0{\cdot}5, 18 \text{ deg.})]}{(36, 103 \text{ deg.}) - (24, 97 \text{ deg.})}$$

$$= \frac{(27, 62 \text{ deg.})\,(8, 60 \text{ deg.})\,[1 - (0{\cdot}5, 18 \text{deg.})]}{(36, 103 \text{ deg.})\,[1 - (0{\cdot}667, -6 \text{ deg.})]}$$

$$= (6, 14 \text{ deg.}) \cdot \frac{1 - (0{\cdot}5, 18 \text{ deg.})}{1 - (0{\cdot}667, -6 \text{ deg.})}$$

$$= \frac{(6, 19 \text{ deg.})\,(0{\cdot}547, -6{\cdot}5 \text{ deg.})}{(0{\cdot}345, 12 \text{ deg.})}$$

$$= (9{\cdot}52, 0{\cdot}5 \text{ deg.}).$$

The correcting weight to be added in plane 1 is $-\bar{a}$ and is therefore (9·52, 179·5 deg.); that is, 9·52 units of weight at a position lagging on the reference position by 179·5 deg.

Some expressions for the analytical calculation of $\bar{c}$, &c., were given in the discussion of the calculations for method 2. The calculation of these expressions is carried out by the process just described for the calculation of $\bar{a}$ and $\bar{b}$, and should present no difficulty.

(To be continued)

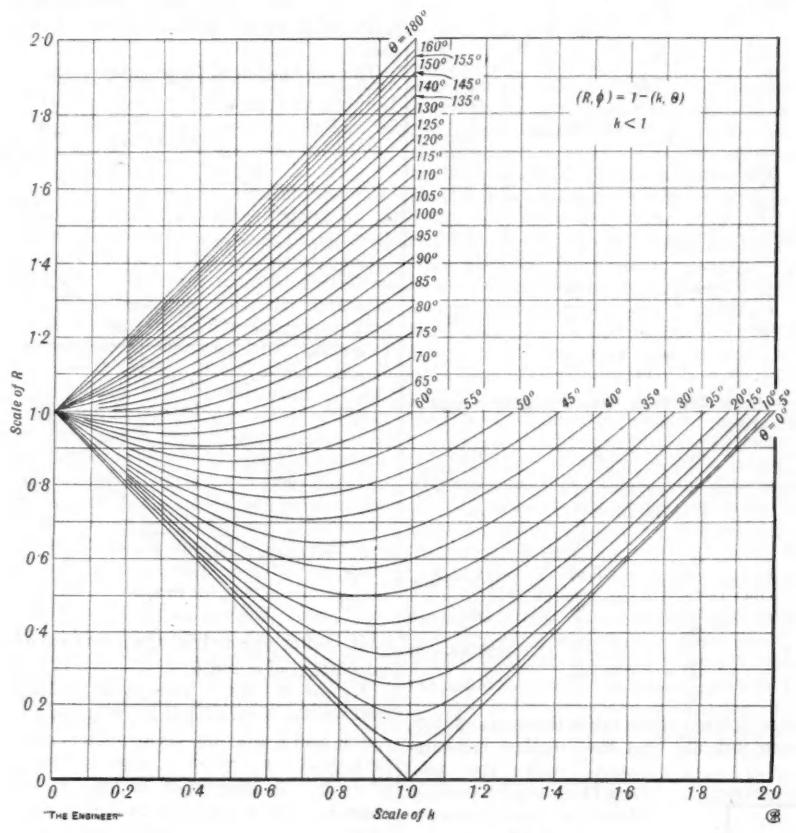

FIG. 7

Water Requirements for Rice Irrigation

RICE growing is one of the great agricultural activities in China, and in spite of protracted warfare, with consequent dislocation of all enterprise, it is expected that extensive schemes for new rice plantations will be developed in the future. Such schemes involve special problems of irrigation engineering, since the growth of the plants requires flooding or submergence of the rice fields. In view of the prospects for rice growing on a large scale in China, investigations have been made as to the water requirements or water duty for rice fields in China and other countries. The studies have covered both the total amount of water required and its distribution throughout the irrigation season.

When new projects are planned for a region in which rice growing is already established, the logical procedure for determining the quantity and distribution of irrigating water would be to measure for a term of years the demand or consumption of water on small selected plots of land already under cultivation. However, funds and time conditions rarely permit of such actual observations, and the probable requirements must be estimated from or based on investigations and records in other regions. The investigation here noted included China, India, Java, and the United States. With differences in soil, climate, and varieties of rice, there is a wide difference in the amount of water used, ranging from 24·67in. for the season in the Kwantung province of China to 140·50in. in California. Of the total amount in Kwantung, 5·12in. was for preparation

of the field before submergence and 19·55in. during submergence.

In some of the cases studied, the amount of water used during each stage of the plant growth was determined, as well as the total depth requirement. In other cases, additional information was gathered as to the loss from field evaporation, transpiration, and seepage. Some of the general results and average climatic conditions are summarised in Table I. In this table a peculiar feature is the extremely wide variation in water requirements in California, the range being from 47·50in. (in clay) to 140·50in. (in loam). This is attributed to the differences in soil, since all the California observations were made in the same district and with the same climatic conditions. On the other hand, the observations in the rice fields of the South-West section of the United States—Louisiana, Arkansas, and Texas—were quite uniform, averaging 30in., owing to similar soils, subsoils, and climatic conditions. The greater

TABLE I

	Average depth of water in irrigation season.			Rainfall.	Evaporation.	Temperature.	Humidity.	Irrigation season.
	Prior to submergence.	Submergence.	Total.					
	Inches.	Inches.	Inches.	Inches.	Inches.	Deg. Fah.	Per cent.	Days.
China	5·12	19·55	24·67	19·55	19·36	81	84	100–135
India	7·88	51·79	59·65	29·00	35·82	81	—	154
Java	15·68	28·33	44·01	47·70	23·55	80	84	133
United States;								
California ...	9·85 to 26·80	—	47·5 to 140·5	1·51	49·28	70	56	154–174
South-West..	—	28·04	31 to 37	19·35	23·00	70 to 80	83	90–120

requirement in California, as compared with the other American region, is due to the high total evaporation during the irrigation season—about 49in.—which results from lower humidity and higher wind velocity.

The observations in China showed a smaller water requirement in the province of Kwantung than in that of Kiangsu, owing apparently to lower transpiration loss and lower seepage loss. The reason for the former has not been determined, but the difference in seepage is attributed to a high ground-water level, or water table, in Kwantung. Larger values in India are due to high evaporation and a long irrigation season.

According to the report, the duty of water for rice irrigation may be divided as follows:—(1) Evaporation from the water surface of the rice field; (2) transpiration of water by the rice plants; (3) seepage of water through the ground; (4) initial application of water to prepare the ground for cultivation and to supply the water for the first submergence. The first three of these divisions are classed as losses during the submergence period, and their proportions vary—as shown by Table II—according to the

TABLE II

	China.				United States (South-West).	
	Inches.	Per cent.	Inches.	Per cent.	Inches.	Per cent.
Evaporation	8·54	23·7	9·28	47·5	10·10	36·0
Transpiration	15·48	43·2	6·85	35·0	16·38	58·5
Seepage ...	11·88	33·1	3·42	17·5	1·56	5·5
Total ...	35·90	100·0	19·55	100·0	28·04	100·0

variety of rice, the method of irrigation, the length of irrigation season, and the climatic differences. The distribution of loss through the three divisions is not uniform throughout the irrigation season, evaporation being greater and transpiration less during the first part of the season. Seepage loss may range from 0·02in. per day in impervious clay to 0·125in. in pervious clay, 0·25in. in clay loam, and 0·45in. in loam.

In experiments with the transplanting method of seeding the field for rice growing, as used generally in China, the water required in preparing the soil for a period of fifteen days before submergence was 5·17in., with an average daily loss of 0·059in. by seepage. The difference between the total amount of water and the total seepage, before submergence, was about 4in. In California, where the broadcasting method of seeding is used, the total amount of water before submergence, and minus seepage loss, was also about 4in. On the basis of the experiments and observations an empirical formula has been prepared to give the total net duty of water, or total inches of water, on the rice field for the entire irrigation season. Results thus obtained are in close accordance with observed values on actual fields, the slight difference between them being largely in transpiration.

The report from which the preceding information is taken was prepared by two Chinese engineers, Mr. T. T. Cheng and Mr. C. L. Pien, who carried on their investigations at the University of Iowa, U.S.A., with the assistance of Mr. E. W. Lane, Professor of Hydraulic Engineering.

AMERICAN TANKER BUILDING PROGRAMME.—With the award of contracts for construction of three single-screw "national defence" tankers, the United States Maritime Commission announced that it has completed its original tanker programme conceived as one of the first requirements for rehabilitation of the American Merchant Marine.

Sixty Years Ago

COLLIERY EXPLOSIONS

AT one time coal mines were ventilated by the crude and dangerous expedient of maintaining a fire at the foot of the upcast shaft. Sixty or seventy years ago the introduction of the Guibal fan made it possible to secure the required ventilation by purely mechanical means. Nevertheless disastrous colliery explosions continued to occur. The winter months were believed by many to be particularly favourable to the occurrence of explosions in mines. Hence, when in the summer of 1880 explosions took place on a heavy scale at several mines—Risca, Leycett, and Seaham, to mention three—there was perhaps some excuse for those who expressed the view that colliery explosions were inevitable and that all that man could do by way of improved equipment and methods of working would not avoid their occurrence. The Risca disaster seemed particularly to emphasise the truth of this pessimistic conclusion. It occurred in the early hours of July 15th, 1880, and involved the deaths of 120 men, almost the whole of the night shift at work in the mine at the time. The mine was known as the New Black Vein Colliery to distinguish it from an older adjoining mine at which twenty years previously a similar disaster had occurred attended with a loss of 140 lives. The new colliery had been laid out under the direct supervision of a well-known Cardiff firm of mining engineers. It was ventilated by means of a Guibal fan in accordance with the latest practice. That the action of that fan was efficient may be judged from the fact that the miners constantly complained of the draught created by it, and, as compensation for the discomfort, demanded extra wages. The mine was highly gaseous and was, further, difficult to work, having a bad top and bottom and requiring much timbering. It was suggested, as usual in such cases, that the disaster had been caused by the use of naked lights. Others suspected that the Guibal fan might have been struck by lightning during the severe thunderstorm which was raging at the time of the explosion. . . . For our part we insisted that while accidents truly so-called might occur, many coal mine disasters were avoidable, and that once their cause was discovered steps to prevent them could be taken. Repeated references to the subject in the pages of our second half-yearly volume for 1880 make it clear that some engineers were beginning to suspect the vital part in propagating colliery explosions played by coal dust. That such dust was highly explosive had been amply proved. It was known, too, from bitter experience that the dust in flour mills was also highly explosive. That deduction had been clearly established by a disaster some years previously at the Tradeston flour mills at Glasgow and more recently by a still more serious explosion in a number of flour mills in Minneapolis.

American Engineering News

Pitting of Stainless Steel

Investigation of corrosion of stainless steels by pitting has been reviewed in a paper before the American Society of Mining and Metallurgical Engineers, and it is concluded that such pitting is caused by breakdown of passivity at localised areas through electrolytic action. Potential differences on the surface give rise to corrosion products at the focus of corrosion, and such differences may be established by inclusions or segregations in the alloy or by differences in oxidising concentration of the electrolyte in contact. The corrosion products are largely ferrous salts, acidic in character, which have the property of destroying passivity and establishing a corrosion cell between passive and active metal, the operating potential difference being about 0·5 volt. If these products accumulate in a pore or fissure on the surface of the metal, the high potential difference of the cell is maintained, and pitting results, its rate depending on the efficiency of depolarisation at the cathodic areas surrounding the anodes or pits. Because of the non-corrosive character of the surrounding metal, the corrosion tends to grow deep instead of spreading. Two factors for rapid pitting in stainless steel are:—(1) A sufficient concentration of chloride ion, and (2) a sufficient oxidising potential of the corroding solution. Stainless steels having surface cracks and fissures have lower corrosion resistance, since these defects permit accumulation of corrosion products formed by slow general solution. If these products do not accumulate, oxygen or oxidising solution diffusing to the attacked area will tend to re-form the passive state and so prevent growth of corrosion pits. Stainless steel containing 0·2 per cent. of selenium was found to corrode more than twenty times as much as a similar chromium-nickel steel free from selenium. The same applies to steel containing sulphur. The process is the same whether the corrodent is ferric chloride or sodium chloride, but the former acts more rapidly.

Electric Power for Dredges

In hydraulic or suction dredges any increase in overall efficiency of the main pump results in material reduction of power costs, and such reduction on large American dredges has been effected by the introduction of electrical control systems adaptable to dredge pump characteristics of constant torque or constant horse-power at variable speeds. Constant speed for such pumps has numerous objections, and usually the pump is adjustable in speed to meet variations in hydraulic head. Where the dredge operates on alternating current supplied through a cable from shore connections the main pump is driven usually by an induction motor with adjustable secondary resistor or a liquid rheostat to regulate the speed. But the loss of power in the resistor is considerable, and the new control systems reduce these losses and consequently reduce operating costs materially. Instead of the energy being dissipated by heat, it is either returned to the line as electrical energy, with constant torque arrangement, or to the main motor as mechanical energy, with the constant horse-power arrangement. In self-contained all-electric steam-powered dredges, the control system would result in fuel saving similar to those for dredges served by electric cables from shore. For oil-engined dredges, all-electric operation has several advantages, and resistor losses may be reduced by speed adjustment of the main pump motor and other adjustable-speed motors by a system of field control. A powerful oil-electric dredge with 30in. pump is equipped with a control system of this kind. Another large dredge, with 28in. pump, was equipped originally with a wound-rotor induction main motor and starting control, but when changed over to a constant-torque control system, the savings due to power consumption, operating time, and increased yardage pumped were sufficient to write off the cost of the change in less than a year.

American Agricultural Engineering

Developments in the mechanical side of agricultural engineering in America are influencing the efficiency of farm operation. In particular, the engineering colleges are carrying out many investigations in general research, and the practical application of scientific methods. One line of recent study is the relative effect of steel and pneumatic tyres on farm soils. The former are found to make a deeper track or rut, 1·3in. to 10·5in., as compared with 0·8in. to 5·8in. for the latter. Much more soil adheres to the steel tyre, its thickness being 1in. to 1½in. on soil and stubble, while on the pneumatic tyre it is only 0·1in. to 0·3in. Pneumatic tyres have usually a 20 lb. pressure, but there are indications of better results at 10 lb. pressure. With steel wheels a flat tyre is better than either a convex or concave form. With pneumatic tyres anti-skid designs obtain their action at the expense of 15 to 25 per cent. greater rolling resistance. The tread design of pneumatic tyres seems to have little importance in regard to rolling resistance. Tests of single, tandem, and dual arrangements of wheels having pneumatic tyres showed little difference in rolling resistance of the single and dual, but considerable reduction with the second. Thus power economy may be obtained by arranging the wheels of field equipment to track whenever practicable. The mean reduction in rolling resistance due to the pneumatic tyre is about 28 per cent., especially in rough soil. Variations in speed from 2 to 5 miles an hour appear to have no important effect on this resistance. There has been a steady increase in the use of ploughs and other tilling tools mounted on tractors instead of being hauled as trailers. The combination is more compact; of less total weight and cost, and can be handled more effectively at corners and along fences. On the other hand, the plough is less easily detachable. Control of depth and width of cut appears to depend more upon individual design than on whether the plough is mounted on the tractor or separate from it.

TRANSPORT PROBLEMS IN FRANCE.—It is reported from France that the transport problem is critical. Monsieur Piétri, Minister of Public Works, has stated that roads, railways, waterways, the telegraph, telephone and wireless systems were all crippled by the destruction caused by the war. More than 700 road and railway bridges are reported to have been destroyed and some 800,000 officials are still dispersed all over France. Since it is difficult to bring them back to their places of work, repairs of communications must be slow. The task, it is thought, may occupy 100,000 workers for several months.

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SKILLED LABOUR

As "Hope deferred maketh the heart sick," so it may be said that "Danger deferred slackeneth effort." In the months of waiting for warfare to begin signs of boredom began to be seen in the factory and the workshop. Zeal began to be replaced by languidness; people began to talk of an economic and bloodless victory; the dread of air attack grew less and less, and the keenest of A.R.P. workers found difficulty in keeping red-hot when the public was lukewarm. All that was changed in a moment. Germany started the war in earnest and the heart of Great Britain began to beat faster. Then Italy sprang into the arena, and the total collapse of the French people and their army soon followed. Normandy, Britanny, and the whole coast of France fell into the hands of the enemy, and the position of this country became perilous in the extreme. Then this Kingdom awoke indeed. Under the energetic leadership of the Prime Minister, Mr. Morrison and Mr. Bevin and Lord Beaverbrook called for such an effort as no country has ever made. The output of materials for the re-equipment of our Expeditionary Force and of aeroplanes shot up. Men and women worked day and night, the factories were never at rest, and the immediate danger was removed. The impossible had been accomplished.

But that had been done under the stimulation of imminent peril and the nervous excitement which accompanies such conditions. It is physically impossible to keep keyed up to that pitch indefinitely. Both the spirit and the flesh rebel against it; zeal begins to flag, enthusiasm wanes, and the output per worker falls away from the peak it had attained. That has already begun to happen, and the Government has very wisely decreed that reorganisation of working hours shall be made at once so that all operatives may have reasonable periods of rest. It is believed that with such refreshment the output per worker can be maintained at a very high level, and that the total output of the country will not fall far short of that reached in the peak period. There is no reason why it should. We have from the first urged that whenever and wherever possible the three-shift system should be employed. Thus would the existing equipment be made capable of much increased output, whilst excessive hours of work, including overtime, would be avoided. Three equal shifts of eight hours, with a proper system of rotation, put no undue strain on the worker, whilst giving the maximum utilisation of plant. We are familiar with the reasons which render three shifts impracticable in every works or in all parts of every works. One of the greatest is the provision of sufficient skilled workers. That difficulty has got to be met, and is to be met by intensive training of selected men and by other means. Another difficulty is that in certain classes of work it is, if not impossible, at least inconvenient and inefficient to change the gang working on them. The incoming workers cannot immediately take on where the outgoers have left off. But if every allowance be made for factories in which the three-shift system is unworkable there still remain many to which it is quite suited and others which, with careful organisation, could be so arranged that three shifts could take the place of two. But with few exceptions the three-shift system requires nearly three times as many skilled men as the single-shift system, and that is the crux of the problem at the moment. The ordinary labour requirements can be met by dilutees; but the setting and revision of their work must be done by skilled workers. To find those men is one of the imperative tasks that lie before the engineering industries. It can be done if there is the will to do it. Hundreds, perhaps thousands, of skilled men are being employed uneconomically. They must be put to work worthy of them. Paradoxical as it may seem, many of the best men are employed on the worst machines. By their skill they are able to turn out a product of the highest class with indifferent tools. On better machines they would be far more productive. Bitter as it may be to some managers, these men must be released from the indifferent machines and transferred to others of a higher standard and with a better rate of output. The result may be to put a certain number of obsolescent machines out of commission, but it may be more profitable to do that than to waste first-class labour.

This is not the time to discuss the reasons why there is a dearth of skilled operatives. The business before the country now is to find or train them as quickly as possible. With that purpose in view a personal appeal is being made to 9000 firms working for the Government on war production in the engineering and allied industries to assist in the reorganisation of man power. In a letter signed by the First Lord of the Admiralty, the Minister of Supply, and the Minister of Aircraft Production—reprinted on another page of this issue—the recipients are told that it is "essential that in every engineering establishment up-grading and 'training up' should take place to the fullest extent practicable. . . . The greater part of training must be undertaken by employers themselves in their own workshops. The further expansion of Government schemes requires skilled instructors. Every additional instructor must come from industry, but each instructor can produce many semi-skilled men a year." It is well, if not generally, known that a Government department has for some time past been organising a scheme under which inspectors will be sent to works to see that the best use is being made of available man power. It is hoped that these inspectors will be received helpfully and in a co-operative spirit; but in the meantime employers are asked to up-grade all the men possible so that the more highly skilled may be used to increase output in their own factories or be released for transfer to other centres where the need may exist; to increase the facilities for training new entrants and existing employees; and to consider the practicability of "breaking down" operations so that the jobs can be done by workers of less skill. All this would be regarded in normal times as intolerable interference, and it would be unreasonable to expect that there would be no resentment and no opposition. Yet we are confident that at this moment of crisis the large majority of employers will bury their personal feelings and co-operate with the Minister of Labour and National Service in an endeavour to meet a real and urgent need of the country. They will have the knowledge that by the sacrifice of some of their own privileges and rights they will hasten the time when their efforts shall be crowned with victory.

Patents and Colleges

IDEALISTS believe that there is an urge in men which impels them to do public good even without hope of reward. Realists, on the other hand, contend that whilst such an urge may, indeed, exist, the spur of reward is needed to stimulate it to the highest activity. The good deeds of philanthropists do not overthrow this contention. More often than not the philanthropist is a person already blessed with the world's goods, who distributes from his superfluity. Moreover, in many instances his riches have been earned by exertions made originally for the sake of profits and rewards. He could not have been a benefactor if he had not in the first place used his talents for his personal advantage. Nor must we take the endless kindness of human beings one to another or the pleasure and pride which many take in public service as a sure sign that men would give of their best without hope of reward. The nature of the reward cannot be, defined. In some cases—Faraday was a shining example—a financial return of small proportion is sufficient; in others, the respect of the world is enough, and in yet others, honour awarded to them by those of their own profession and vocation is adequate stimulation. But, however tenuous the recompense may be, rarely or never is it found, even in the purest of pure science, that achievement alone is sufficient. Scientists may modestly hide their lights under a bushel, but they take care that their name is stamped on the outside!

In an address delivered a few months ago, Mr. A. A. Potter, Dean of Engineering at Purdue University, discoursed on "Research and Invention in Engineering Colleges." The conclusions at which he arrived are reprinted on another page. The last of them runs thus: "Industries co-operating with educational institutions find that a considerable number of colleges and universities through a sound patent policy are in a position to protect the findings of the research laboratory, while encouraging creative talent and reward for accomplishment." But not all American universities and colleges have corporate patent policies. Out of thirty-nine, about one-third regard patent rights as outside their jurisdiction. They consider the patenting of inventions and processes to be the affair of the individual; they do not busy themselves in the matter and ask for no share in any profits that may accrue, even though the invention arises directly from work done in the college laboratories. With no more than one or two exceptions that is the practice followed in this country. Indeed, it might almost be said that here we encourage the teaching staffs of universities to engage in lucrative work in order to augment inadequate salaries. On that much might be said, but we do not propose to say it at this moment. There is another difference between American engineering colleges and ours which affects Mr. Potter's conclusions. In the United States educational research departments devote more time to industrial research than ours do. It is, no doubt, a consequence of that fact that more opportunities for industrially useful inventions arise and that the colleges have found it desirable to have patent systems by which some of the profits—if any—

may be reserved for the college. But taken for all in all it does not appear to be a very remunerative business. Out of sixteen State-supported institutions holding 380 patents, only five report any profit from that source. It may be that the colleges are, in fact, not much concerned about the pecuniary value, to them, of the inventions. They take out patents, perhaps, not so much with a view to gain as on the Elihu Thomson principle. "Publish an invention freely, and it will almost surely die from lack of interest in its development. Patent it, and if valuable, it will be taken up and developed into a business." Mr. Potter says: "In making the products of the laboratory available to society, colleges and universities have found that dedicating the findings of research to the public actually withholds these findings from use." That is a hard saying, and we are confident that Mr. Potter recognises that it can only be accepted with reservation. It may be applicable to specific inventions; it certainly is not where fundamental research is concerned. If it were, more of the research done in laboratories and colleges would have little value beyond academic additions to the world's stock of knowledge.

It would be unjust to conclude from what we have said that the real attitude of American engineering colleges is different from that of British colleges. They have entered into these schemes with much less view to personal profits than in the belief that their researches are more likely to be rendered useful to the public if they are protected, and because the patent is a form of reward which stimulates the creative and inventive talents of research workers. Mr. Potter makes all this quite clear in his last paragraph, which is a corrective to an unjust and cynical view of the activities of American engineering schools: "Scientific research is the main concern of higher education, with reward to the institutution and inventor as a secondary consideration," he writes, and adds, "inventive ability is placed on the same level as good teaching and good relationship with the public, and the creation of new scientific knowledge is recognised and rewarded." Those words indicate a line of development which is worthy of consideration. It would appear that the American engineering schools are endeavouring to foster "inventive ability." If college patents can do that their obvious disadvantages will be more than outweighed by their advantages.

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A Study of the Fire Resistance of Building Materials. By H. D. Foster. Ohio, U.S.A.: Engineering Experiment Station, Ohio State University, Columbus. Price 60 cents net.

Automatic Design of Continuous Frames in Steel and Reinforced Concrete. By L. E. Grinter, Ph.D. London: Macmillan and Co., Ltd., St. Martin's Street, W.C.2. Price 12s. 6d. net.

Freehand Drawing and Pictorial Illustration for Draughtsmen. By W. H. Kerry and E. W. Scott. London: Draughtsman Publishing Company, Ltd., 1, Links Road, Epsom. Price 2s. net.

Report on the Water Resources of Transjordan and their Development. By M. G. Ionides, B.A., A.M. Inst. C.E. London: Crown Agents for the Colonies, 4, Millbank, S.W.1. Price 30s. net.

Air Force Targets in Germany

No. II

(*Continued from page 28, July 12th*)

THE DORTMUND-EMS CANAL

IN that section of our last article which dealt with the German railway facilities at Hamm, we made reference to the great damage which had been caused in marshalling yards and railway centres by the repeated attacks on these targets by aircraft of the Bomber Command. Other targets in the same area have included the marshalling yards at Osnabrück and Soest, and railway junctions near Cologne. The result of these attacks, often carried out at frequent intervals, has been to disorganise seriously the flow of traffic eastwards from the Ruhr district to North and Central Germany and to reduce the transport of iron ore and other raw materials needed by the factories in the Dortmund industrial area.

With a view to remedying to some extent this traffic dislocation, recourse has been had to a more intensive use of the well-planned inland canal system of Germany, which connects the River Rhine with the cities and towns of Central and North Germany, and the North Sea ports of Emden and Wilhelmshaven—both naval bases—and Bremen and Bremerhaven, which are reached through the Ems-Jade and Ems-Weser Canals and the Kustenkanal.

Reconnaissance flights made by the Royal Air Force showed that large barges, big enough to carry two trainloads of goods, were being employed to carry munitions. Various stretches of the canal—see Fig. 1—were photographed, particularly the aqueduct where the canal crosses the River Ems. One of the earlier photographs showed clearly twenty barges on one stretch of the canal, a clear indication of the importance of the target. In order to make quite clear to the crews of the bombers the nature and appearance of the target to be dealt with, models of the aqueduct were constructed, and special instructions were given on the method of attack to be adopted. These precautions proved very valuable, as it was reported by the captain of one aircraft that there were several places on the canal which more or less resembled the objective target. On the night the canal was attacked bright moonlight favoured the raiders, and bombs were dropped in the aqueduct and near the stop gates and against the embankment. All our aircraft returned undamaged. Subsequent photographic reconnaissances showed the success

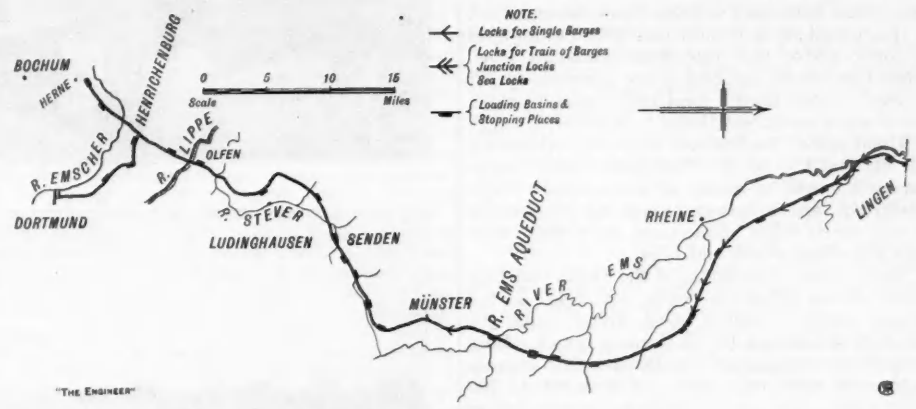


FIG. 1—MAP OF THE DORTMUND-EMS CANAL

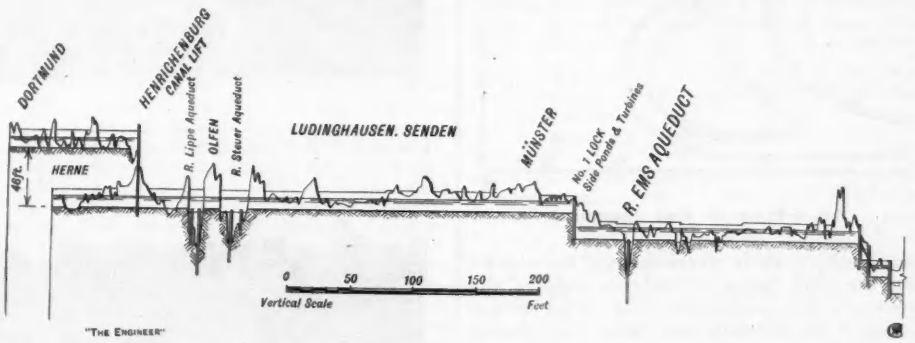


FIG. 2—PROFILE OF THE DORTMUND-EMS CANAL

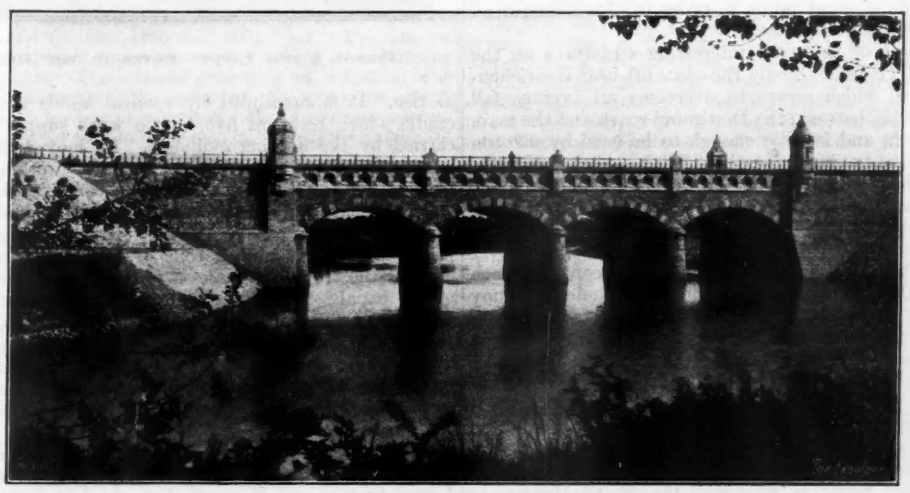


FIG. 3—EMS AQUEDUCT ACROSS RIVER EMS

of the attack. Barges were seen high and dry in the mud whilst the aqueduct and the adjoining stretches of canal were empty. Several barges were seen to be unloading their cargoes in a field alongside the canal, giving further evidence that the task had been successfully accomplished.

In the accompanying drawings we reproduce a plan and section of the Dortmund-Ems Canal, showing the connections from Dortmund and Bochum as far as Lingen. This canal was sanctioned in 1886 and Dortmund was fixed for its starting point. It was completed in 1899. A connection to the Rhine was completed in 1914 to 1915 and the eastern section of the canal was connected with the Weser at Minden by means of the Ems-Weser Canal. The distance from Dortmund to Emden is 168 miles, the branch from the main canal to Herne being 7 miles long. The summit level of the main canal between Dortmund and the canal lift at Henrichenburg is 9½ miles long with a water level of 230ft. above the Amsterdam standard level. From this reach the barges are lowered by lift to 184ft. above datum level into the main reach below which runs from Herne to Münster, a length of 41·66 miles. At Münster there is a lock with a fall of 20·3ft. into the Mittelland Canal reach, having a length of nearly 23 miles with a water level 164ft. above datum. From the termination of this reach other connections have been built with the rivers Weser and Elbe.

The principal dimensions of the Dortmund-Ems Canal are as follows:—Depth, 8ft. 2½in., and a bottom width of 59ft., which accord with the standard dimensions for all German canals. More recently the canal has been widened so that whereas in the first canal only barges of from 600 to 700

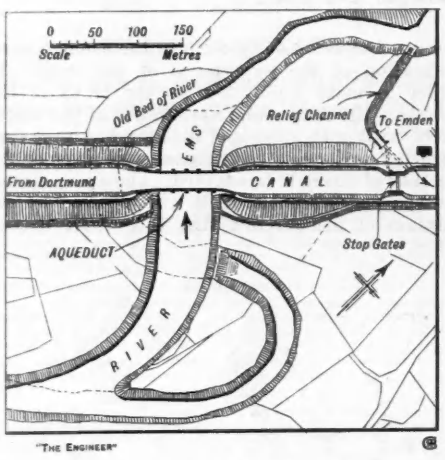


FIG. 4—PLAN OF EMS AQUEDUCT

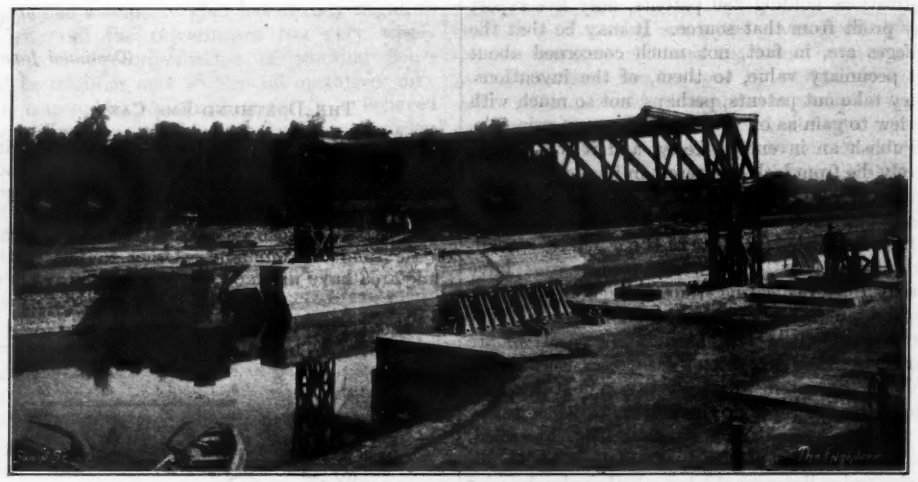
tons capacity could be accommodated, the widened canal can carry barges of 1000 tons capacity, this increased width corresponding to the newer sections of canal on the Mittelland and Ems-Weser systems. The 1000-ton barges have a length of 262ft. 6in. with a beam of 34ft. 6in. and a draught of 5ft. 3in., while for canal lighters the corresponding measurements are length, 262ft. 6in.; beam, 29ft. 6in.; and the draught, 6ft. 6in. The section of the canal is such that at normal level two of the large craft can pass each other safely and leave sufficient clearance from the bed and slope of the canal. Most of the canal slopes are protected by stone pitching or cement concrete slabs, and when the widening operations were carried out free use was made of sheet piling in order to obtain increased cross-sectional area.

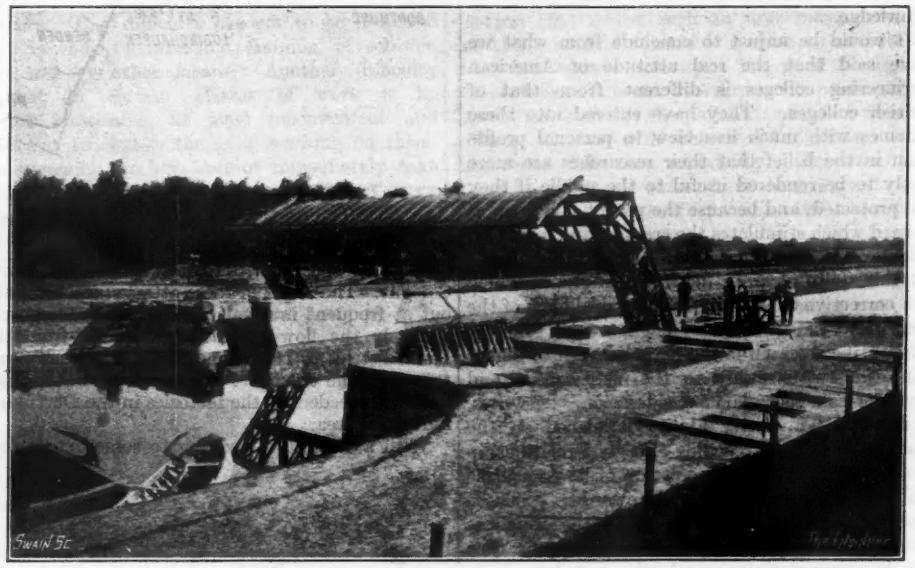
One of the most interesting structures on the canal is undoubtedly the canal lift near Henrichenburg, which serves to overcome an average fall of 46ft. between the Dortmund reach and the main reach, and is large enough to be used by 950-ton barges having a length of 220ft., a beam of 27ft., and a draught of 6ft. 7in. This lift works on the floating principle, having a single trough moving in parallel guides. The sub-structure comprises five wells lined with cast iron cylinders, each over 30ft. in diameter and over 98ft. deep. In each well there is a floating hollow cylinder or buoy having a diameter of 27·25ft. and a length of 32ft. 10in. Together, these five hollow cylinders exert an upward pressure of 3100 tons, which is equivalent to the weight of the trough when full of water, plus the weight of the five vertical supports on which it rests. The whole construction is so arranged that when the tank is filled with water it is in perfect equilibrium, so that if any extra water is admitted the trough begins to sink or if any water is run out the trough begins to rise. It is suspended by vertical bands in a cradle which rests on five lattice work supports carried by the floating cylinders. Its movement is controlled by four vertical spindles working in four nuts attached to the cradle carrying the trough, these spindles being operated simultaneously by a single driving shaft. Wedge pieces with india-rubber rolls are fitted to the ends of the trough to make a joint with the end of the canal. This lift was built by Haniel and Lueg, of Düsseldorf, and the time occupied for raising one barge and lowering another averages twenty-five minutes. The actual raising and lowering of the trough occupies only 2½ minutes, the remaining time being needed for manœuvring the barges.

Other important structures on the canal are the aqueducts, which carry it across the rivers Lippe, Stever, and Ems, the last of which is the target described in this article. Each of these aqueducts is built of masonry, the largest being that over the Ems, which we illustrate in Figs. 3 and 4. This aqueduct has four arches and the masonry abutments are lined with a layer of clay puddle from 12in. to 27½in. thick, which joins the corresponding layer of puddle of the embankment. In addition the structures were made water-tight with sheet lead 0·12in. in thickness.

For the purpose of dividing the canal into isolated reaches, stop gates embodying a new principle of construction were adopted. They enable sections of the canal to be isolated in the shortest time. These stop gates are placed at frequent intervals. Three engravings reproduced herewith show one of these gates in the raised, half-lowered, and lowered positions. The canal at the site of the gate is enclosed between two parallel vertical walls, leaving a passage of 59ft. width between them. This passage is closed by a curved steel gate which consists of a single

STOP GATES ON THE DORTMUND-EMS CANAL





FIGS. 5, 6 AND 7—STOP GATES IN THE RAISED, HALF-LOWERED AND LOWERED POSITIONS

skin stiffened and strengthened by suitable framework. When not in use, the gate is swung out of the water round a horizontal axis and stretches like a hood or shield across the passage formed by the two parallel walls, being raised to a sufficient height above the water to give the necessary headway for barges passing underneath. The stop gate is moved by two arms resting on a pair of trunnions which revolve in bearings embedded in the side walls. The arms are prolonged downwards and oscillate in slits formed in the walls, counterweights being provided which automatically change their positions while the gate is being swung round, thereby controlling its movement. When opening or shutting the gate, the whole structure and motion remains in equilibrium in every position. Various experiments were made with these gates, and led to a more and more simple construction of the apparatus, the final form of both the gate and the machinery performing their functions in a most satisfactory manner. The stop gates and the machinery for working them were designed and made by the Gutehoffnungshütte, of Sterkrade. Each stop gate is closed by an attendant who lives on the spot and whose duty it is to shut the gate immediately on receiving a warning signal. In the side walls of the canal, culverts are provided which lead to relief channels. By means of these it is possible to adjust the level of water in the two reaches separated by the gate. In order to drain off any surplus water which may find its way into the canal during extraordinarily heavy rains, outlets have been provided in suitable places, having due regard to the situations of the stop gates.

To supply water to the canal there is a pumping station on the banks of the River Lippe, raising the water by means of centrifugal pumps to a height of 51·66ft. In addition to this pumping station, the canal is also fed by natural watercourses which have been diverted for this purpose. When the canal was begun in 1893, a sum of £3,234,000, which was subsequently increased to £3,971,500, was set aside for its construction. This works out at about £25,438 per mile for the length of 156·66 miles constructed. The canal was officially opened on August 11th, 1899.

At Dortmund and Emden well-laid-out harbours have been constructed.

Tests of 28ft. Span Aluminium Alloy Trusses*

By R. L. TEMPLIN, E. C. HARTMANN, H. N. HILL.

INTRODUCTION

A TRUSS is one of the most common and useful built-up structural elements and frequently is well suited for various types of light-weight construction. For the purpose of studying the behaviour of this type of structure, made from aluminium alloy shapes and plates, a truss of 28ft. span was designed, this span representing the maximum which could be conveniently tested with the available equipment. Since a lack of lateral stability makes it almost impossible to test an individual truss, two trusses were built and incorporated into a single structural unit with a conventional system of lateral and transverse bracing.

The alloy used in the construction of this experimental structure was Alcoa 17S-T, a heat-treated aluminium alloy containing approximately 4 per cent. copper and fractional percentages of manganese and magnesium. This material, frequently referred to as duralumin, has the typical properties shown in Table I. It should be appreciated that since all stresses in these tests were kept within the elastic range, the results of this investigation are not restricted to structures of alloy 17S-T, but are applicable to other wrought aluminium alloys.

TABLE I.—*Typical Properties of Alcoa Alloy 17S-T*

Tensile strength...	60,000 lb. per square inch
Yield strength (0·2 per cent. set)	37,000 lb. per square inch
Elongation (in 2in.)	22 per cent.
Modulus of elasticity	10,300,000 lb. per square inch
Poisson's ratio	⅓
Weight	174 lb. per cubic foot

The structure on which the tests were made consisted of two Pratt trusses, 5ft. deep and 28ft. long, divided into seven 4ft. panels. Each truss was designed for a single concentrated static working load of 17,000 lb. applied at any panel point. The two trusses were spaced 42in. centre to centre and fastened together by lateral bracing in the planes of the chords and by transverse cross bracing between the posts. The overall weight of the completed structure was approximately 1200 lb.

The structure was built of 17S-T angles and plates. The truss on which most of the measurements were made was assembled with ⅞in. steel Dardelet rivet bolts† so that changes could be made in various parts. The other truss was assembled with ⅞in. 17S-T rivets driven cold within one hour after heat treatment. The bolts and rivets were not placed on the normal gauge lines of the angles, but were placed on working lines as close to the centroidal axes as possible.

During the progress of the tests the following changes were made in the truss assembled with Dardelet rivet bolts :—(1) The original ⅜in. thick gusset plates were replaced by plates of the same shape, but ⅝in. thick ; and (2) one angle of each of the double-angle web members was removed.

TESTING PROCEDURE

The structure was supported in the inverted position at the ends of the upper (tension) chords by means of four long steel tension bolts threaded into inserts in a reinforced concrete test floor slab. For each loading both trusses were loaded simultaneously at the same location with single concentrated loads applied upwards with two 30-ton Blackhawk hydraulic jacks which had previously been calibrated. The position of application of the load was varied in the different tests. Loads at panel points were applied to the bottom (compression) chords through 5in. square aluminium bearing blocks.

With the exception of truss deflections, measurements were confined to the truss assembled with the rivet bolts. Deflections of both trusses were measured at each panel point on the upper chord. Polished aluminium mirrors on which were mounted paper scales graduated to $^1/_{50}$in. were fastened by angle brackets to the top of the upper chord at each panel point. A fine wire was fastened at one end panel point of the chord and stretched in front of the mirrors over a pulley at the other end panel point. Constant tension was provided by a weight on the end of the wire. With this arrangement the position of the wire could be read with an accuracy of ±0·002in. A similar method was used for measuring deflections of the individual members, the mirrored scales being fastened at several locations on each member, tension in the wire being maintained by rubber bands.

Changes in distances between panel points of the bolted truss were measured between steel pins fastened at each panel point. Distances between these pins were measured with a $^1/_{1000}$in. dial indicator on the end of an adjustable rod. Measurements were made on both sides of a member.

Strains were measured on 2in. gauge lines at numerous locations on the truss, using Berry strain gauges. Strains were determined with a probable error corresponding to a stress of about ±500 lb. per square inch. Compensation for temperature changes was made by the use of a standard bar of the same material as that used in the truss, placed on one of the chord members of the truss. Strains were also measured on the gusset plates at locations on the edges of the plates and also at intersecting gauge lines on both sides of the plates. Directions and magnitudes of the principal stresses were determined from strain measurements on the rosettes. Stresses on the edges of the gusset plates and at the various locations on the members were determined by multiplying the measured unit strains by a modulus value of 10,300,000 lb. per square inch.

The locations at which strains were measured on the truss were selected so as to obtain a comprehensive survey of the stress distribution in the various members within the limits of the clearances required to operate the strain gauge. These locations included most of the points at which maximum stresses would be anticipated, with the exception of inaccessible locations in the immediate vicinity of the rivet holes where high localised stresses occur. Such stresses are important in structures which must withstand a great many repetitions of load, but are of minor importance in structures subjected primarily to static loading.

Vibration was induced by impulses from an eccentric fly-wheel mounted on the shaft of a ½ H.P. motor which was supported on a 12in. aluminium alloy I-beam fastened transversely to the lower chords of the two trusses. The speed of the motor could be varied between 1000 and 2400 r.p.m. The load on the trusses was changed by adding or removing weights. The natural frequency of vibration was determined as the speed of the motor at which resonance was encountered. Resonance was accompanied by an unmistakeable increase in the amplitude of vibration.

SUMMARY OF RESULTS

The results of the tests are summarised as follows :

Primary Stresses and Truss Deflections for the Truss with Double Angle Members and ⅜in. Gusset Plates.

1. Average measured stresses in the posts and chord members average about 6 per cent. smaller than corresponding values calculated on the basis of the usual assumptions of frictionless hinges and no participation of bracing in carrying primary stresses. Calculations indicate that if the participation of the double diagonal bracing were taken into account in the calculated stresses, the average difference between measured and calculated primary stresses in the chords and posts would be reduced to about 1 or 2 per cent.

2. The average difference between calculated and measured primary stresses in the diagonal web members is about 2 or 3 per cent. If the shear in the middle panel is assumed to be divided equally between the two diagonals, the calculated primary stresses for these members differ from the measured by as much as 25 per cent. for some loading conditions. When the redundancy is taken into account, however, the greatest difference between calculated and measured values is reduced to about 8 per cent. and the average difference is less than 2 per cent.

3. The measured deflections of the truss for various loading conditions average about 9 per cent. less than the corresponding values calculated on the usual assumptions of frictionless hinges at the joints, no participation of bracing in carrying primary stresses, and no increase in effective areas of members at the joints. Half of this discrepancy can be eliminated if the participation of the bracing is taken into account in calculating the deflections.

4 The riveted truss showed a straight line load-deflection curve. The bolted truss was somewhat stiffer at low loads, but at higher loads both trusses deflected about the same amount.

Secondary Moments and Stresses for the Truss with Double Angle Members and ⅜in. Gusset Plates.

5. There was little evidence of non-uniform distribution of the direct force between the two angles of any member.

6. At sections through the members within a distance from the end connection equal to the width of the member the outstanding legs of the angles did not carry their full share of the load.

7. Measured secondary stresses and moments were in fair agreement with calculated values for all members but the double diagonals of the middle panel and the inclined end post. The discrepancy in the case of the diagonals of the middle panel resulted from the fact that the maximum stresses were measured close enough to the end connections to be considerably affected by the non-uniform stress distribution in the outstanding leg. The stresses in the inclined end post were influenced by the unknown excentricity of the end reactions, produced by the deflection of the truss.

8. For loadings producing maximum secondary stresses in the members the secondary stresses were from 17 to 150 per cent. of the primary stresses. For loadings producing the maximum total stresses in the members the secondary stresses were about 25 per cent. of the primary stresses, except for the double diagonals of the middle panel. The secondary stresses measured in the double diagonals of the middle panel were 65 to 115 per cent. of the primary.

Effect of Loading Excentricity at Panel Points for the Truss with Double Angle Members and ⅜in. Gusset Plates.

9. The bending moments measured in the members meeting at a joint for a load applied excentrically within 3in. of that panel point were in fair agreement with corresponding values calculated by distributing the rotating moment (load times excentricity) among the various members according to their relative stiffnesses (I/L values). The best agreement was obtained by considering the length (L) of a member as the clear distance between the end connections.

10. The deflection of a member was consistent with the bending moments determined from the measured stresses, the member being considered as having a uniform moment of inertia between panel points.

Action of the Joints for the Truss with Double Angle Members and with ⅜in. and ⅝in. Gusset Plates.

11. When assembled with ⅝in. gusset plates the truss deflections were slightly greater than corresponding values measured with the ⅜in. gusset plates. A maximum difference of about 8 per cent. was encountered.

12. There was no definite evidence that the secondary stresses were influenced by the thickness of the gusset plates.

13. The maximum measured tensile and compressive stresses in the gusset plates were from 8 to 57 per cent. of the calculated bearing stresses for the various joints. Since the tensile and compressive stresses are permitted to reach values as high as 60 to 70 per cent. of the limiting bearing stresses in most structural specifications, it follows that if the gusset plates are designed to keep the bearing stresses within safe limits, the tensile and compressive stresses will also be within safe limits.

14. The highest individual measured stress in any gusset plate was a tension of 34,900 lb. per square inch, which occurred in the ⅝in. gusset plate at the joint where the gusset plate acted as a splice between the end post and the compression chord. This stress was 57 per cent. of the calculated bearing stress.

Behaviour of Single Angle Web Members for the Truss with ⅝in. Gusset Plates.

15. With the cross frames unbolted the measured change in length of one compression member (between panel points) was almost four times as great as the calculated value based on the average measured stress in the member. Measured and calculated changes in length agreed fairly well if the calculated values were based on the average measured stresses

* Aluminum Research Laboratories (Aluminum Company of America, Pittsburg).

† These bolts have splines on the shanks which grip the metal when the bolts are driven into the holes.

in the fastened legs. The agreement between calculated and measured changes in length was further improved by adjusting for the curvature of the members.

16. The secondary stresses in the single angle members were from 78 to 129 per cent. of the measured primary stresses, while for the same members with double angles the secondary stresses ranged from 13 to 89 per cent. of the primary. The secondary stresses in the chords were almost twice as great with the single angle web members as with the double angle web members.

17. Unbolting the cross bracing resulted in a considerable increase in bending in the compression members. In one post maximum stresses of 34,000 lb. per square inch compression and 42,100 lb. per square inch tension were measured when the member was subjected to an average compressive stress of 7400 lb. per square inch. A lateral deflection of about 1in. was measured at the middle of this member when so stressed.

Vibration of the Trusses with Double Angle Web Members and ⅜in. Gusset Plates.

18. The fundamental frequency of the structure was about 2000 cycles per minute when loaded only by its own weight (about 1200 lb.). With the addition of dead weight at the middle section the frequency decreased, reaching a value of about 1000 cycles per minute for a dead load of 1870 lb. (935 lb. per truss).

19. The experimentally determined values for the fundamental frequencies were about 5 to 10 per cent. lower than calculated values.

Fire Hazards with Aluminium Paint

THE conditions under which sparking from aluminium painted surfaces occurs have been well established and can now be fairly clearly defined. Tests by an aluminium pigment manufacturer have been confirmed by the recent investigation undertaken by the Safety in Mines Research Board Laboratories, which shows that under certain conditions it is possible to produce sparks by striking an aluminium painted ferrous surface.

When aluminium paint is applied to rusty surfaces of iron or steel and the paint film subjected to temperatures sufficient to break down the elastic structure of the binding medium, cracking and release of the film is liable to occur. If this surface is then struck with a steel or bronze implement a spark or series of sparks may be produced. This has been responsible for the assumption that in the presence of inflammable vapour a fire risk is established. Careful consideration of the facts, however, reveals that a series of conditions must be present before such risk can be established. These conditions, all of which need to be present, are as follows :—The paint is applied to a rust-coated surface ; the paint medium is such as to permit cracking or has been broken down by heating to a temperature of not less than 90 deg. Cent.; inflammable vapour in explosive concentrations must be present ; the paint surface is struck with a metal or other hard material implement.

In reference to these conditions, it is pointed out that, from the viewpoint of maintenance alone, no paint should be applied to surfaces on which loose rust is present ; always in painting procedure is it required that rusty surfaces be cleaned down prior to painting. It is further noted that stringent Home Office regulations now govern the precautions to be taken to eliminate causes of sparking where inflammable vapours are present. The prevention of possible ignition arising from the use of aluminium paint does not appear to require more rigid regulations than those which guard against sparking by impact between ferrous implements or, for example, by shoe nails striking concrete or steel floors, closing gates, and so on.

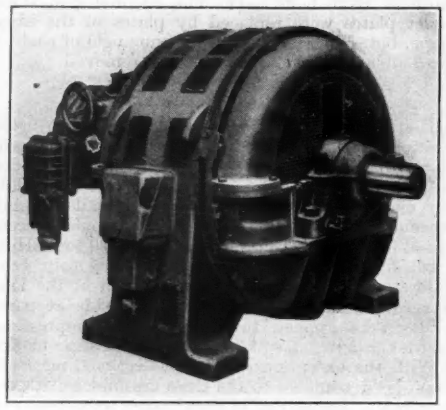
It is understood that the investigations by the Safety in Mines Research Board are being continued.

Heavy-Duty Slip-Ring Motors

BUILT for outputs of 75 H.P. and upwards, heavy-duty slip-ring motors produced at the Witton Works of the General Electric Company are particularly suitable for colliery haulages and similar heavy-duty drives. Electrically they comply fully with British Standard Specifications Nos. 168 and 270, and are wound for pressures up to 3300 volts. Two special features of the machines are (1) the provision of jacking screws to facilitate centring the rotor, and (2) a patented floating gland embodied in the flame-proof slip-ring cover.

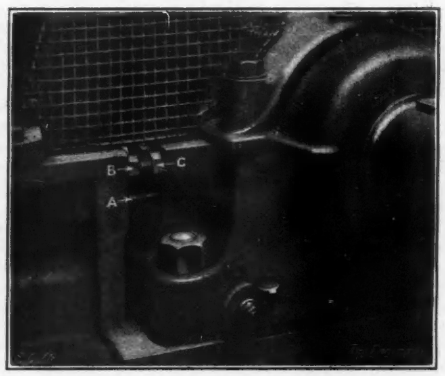
The method of centring the rotor is clearly shown in the view of the bearing, where it will be appreciated that jacking screws A are situated on each side, and the locating bolts B and locking nuts C secure the rotor in position. The bearing pedestal is tapped to receive the jacking screws and locating bolts, which cannot become displaced. Where adjustments have to be made in confined places underground, the simplicity of this arrangement is claimed to be an important advantage.

The patented floating gland, associated with the Buxton certified flameproof covers, and which ensures that the correct shaft clearances are preserved irrespective of wear, is shown in section. It is designed to provide the regulation clearance between the



HEAVY-DUTY SLIP-RING MOTOR

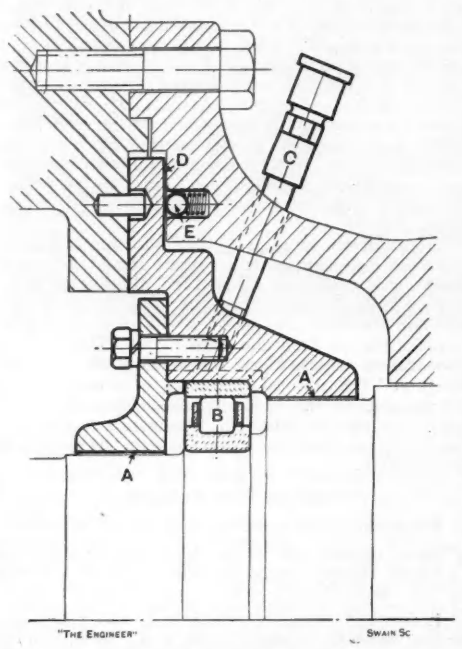
gland and shaft at A, and is mounted on a roller bearing B, the inner race of which is secured to the shaft. This bearing serves to locate the gland and does not carry any further load. Grease is fed to the bearing through the lubricator C. To permit the gland to take up its correct position clearance



CENTRING SCREWS

is maintained between the faces at D by means of spring-loaded balls E, which are fitted in such a manner that they cannot become displaced when dismantling the gland.

Together with the outer race of the roller bearing, the gland can be removed as a self-contained unit,



FLOATING GLAND

leaving the inner race and rollers on the motor shaft. Although designed primarily for use with journal bearings, the floating gland can be fitted with equal success to machines having ball or roller bearings.

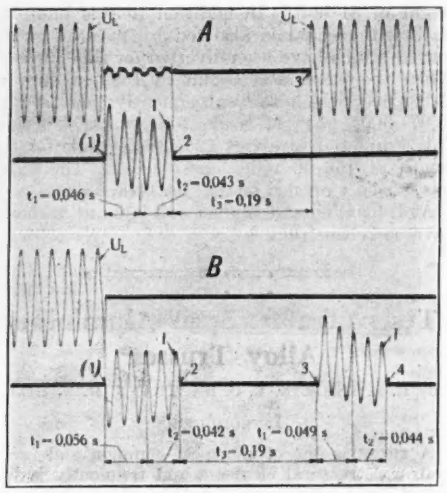
Three important factors govern the design of the terminal boxes : (1) Accessibility, (2) ease of dismantling, and (3) alternative positions for cable entries. The rotor terminals are very accessible. Mechanical connectors are employed so that the cable box can be removed without interfering with the terminals on the machines. Further, the cable box can be mounted in various ways to receive cables rising or falling vertically or entering horizontally. The stator terminal boxes also are provided with mechanical connectors and can be mounted to give a choice of four directions for the cables. Where neutral point boxes are required they are situated on the opposite side of the machine to the terminal boxes. Both boxes are similar in every respect so that either may be used for the incoming supply.

In addition to the advantages described, the motors have heavy overload capacity and ease of access to every part of the machines.

Re-Closing Air Blast High-Speed Circuit Breakers

AIR blast high-speed circuit breakers with rapid re-closing devices, as made by Brown, Boveri and Co., are said to have proved highly successful in dealing with disturbances on electrical systems and reducing their effect to a minimum. At least 80 per cent. of all faults have been found to be of a transient nature and usually originate in single-pole faults to earth. Generally they are the result of direct or indirect lightning strokes on overhead transmission lines, the insulators flashing over under the effect of the over-voltage, thus initiating a short circuit.

The function of the re-closing circuit breakers is to cut off as quickly as possible the power being fed into the fault, and then to switch in the line to enable normal service to be continued. Hence the short-circuit arc is automatically extinguished and the disturbance is practically unnoticed. Two conditions must be fulfilled, *i.e.*, the re-closing of the circuit breaker must



U_L.—Voltage on overhead line about 150 kV R.M.S.
1.—Ruptured current about 2200 A R.M.S.
(1).—Beginning of short circuit.
2.—End of rupturing process.
3.—Instant of re closing.
4.—Final rupture with metallic short-circuit.
t_1 and t_1'.—Relay times.
t_2 and t_2'.—Opening times of circuit breaker.

OSCILLOGRAMS SHOWING OPENING AND RE-CLOSING OPERATIONS OF 150-KV AIR BLAST CIRCUIT BREAKER

follow the opening operation with the least possible delay, but the circuit must remain open long enough to permit the short-circuit arc to be extinguished. To meet the first requirement normal service conditions must be re-established after an interval which may vary between 0·3 and 0·7 second, according to the length of the short-circuit period. Based on unfavourable atmospheric conditions experience has shown that the arc cannot be reliably extinguished unless the circuit is allowed to remain open for at least 0·2 second. The requirements can only be met by a high-speed circuit breaker. As a result of the rapid opening of the contacts the time gained can be added to the succeeding unenergised interval, while the fact that the energy being fed into the short-circuit arc is instantaneously cut off reduces ionisation of the air and in consequence the risk of the arc re-striking.

When considering the re-closing problem a point that must not be overlooked is that the two circuit breakers protecting a section of a line do not operate absolutely simultaneously. Moreover, it is to be remembered that lightning strokes do not usually cause one single discharge, but a series of discharges in rapid succession, which, as experience has shown, always affect the same conductor. Both of these phenomena demand a fairly long de-energised period to enable the fault to be cleared.

In the case of a three-phase system only the phase affected by the short circuit would be cut out. In this way the arc will have time to become extinguished, for the two sound phases will maintain the synchronism of the system. Any apprehensions as

to the voltage induced by the sound phases continuing to feed the short circuit can be allayed by calculations or system tests. The remanent current is, in fact, of such small magnitude that the effect on the extinction of the arc is practically the same no matter whether only one or all three phases are ruptured.

Rapid re-closing, therefore, entails a circuit breaker having a very short opening time and all three poles capable of being operated individually. These two requirements are met by the Brown-Boveri air blast high-speed circuit breakers, which, with their high-speed opening and closing properties, are claimed to solve the problem of system protection. On account of the splitting up of the interrupting components of the circuit breakers into arcing and disconnecting contacts, arranged in series, they can be made to re-close automatically with relatively simple control gear.

At opening the compressed air causes the arcing contact to move a certain distance in the arcing chamber, this distance being in the neighbourhood of a few centimetres and calculated to give the maximum rupturing capacity. The masses of the arcing contacts to be moved are very small and this, together with the good extinguishing properties of the compressed air, results in the remarkably short opening time of 0·05 to 0·06 second. This time is reckoned from the moment the opening impulse is imparted to the extinction of the arc. Under the effect of the compressed air the arcing contacts remain open until the end of the de-energised period, when they re-close.

If the short circuit has disappeared normal service will be resumed and the circuit breaker will again take over the supervision of the system. But if the disturbance proves to be of a permanent nature the extinguishing contacts will re-open and the circuit breaker will this time be definitely switched out. The rapidity of switching ensures the stability of the system being maintained even after the second opening operation, for the total time necessary for the whole cycle of switching operations is only in the neighbourhood of 0·4 second. This time is obtainable as follows:—First opening operation, relay and circuit breaker, 0·1 second; line unenergised, 0·2 second; re-closing and second opening operation, relay and circuit breaker, 0·12 to 0·15 second.

High-speed re-closing of the Brown-Boveri high-speed circuit breakers is achieved in a simple manner. Each pole is equipped with a system of electro-pneumatic valves, a double compressed air distributor and a hollow insulator to conduct the air to the arcing contacts. Systematic tests with a view to developing the Brown-Boveri air blast circuit breakers and the investigations to discover the conditions governing the extinction of short-circuit arcs on overhead lines have proved the above principles to be correct, while service tests confirm the results obtained in the test bay. These are shown by the oscillograms. That shown at A refers to a transient originating in an arc. Before the disturbance the line was carrying the voltage U_L. The arc appeared at the point (1). The voltage disappeared and the oscillograph recorded the magnitude of the arc voltage and the short-circuit current I. This current lasted until the point 2, when the circuit breaker was tripped in 0·089 second, this time being composed of the period t_1 of 0·046 second for the relay to operate and the period t_2 of 0·043 second for the circuit breaker to trip. Thereupon the line remained unenergised for 0·19 second. During this period the short-circuit arc was extinguished and the dielectric strength of the air was re-established. At the point 3 the circuit breaker was re-closed and upon the voltage U_L reappearing the fault was completely cleared. Service was therefore resumed less than 0·3 second later, *i.e.*, the supply suffered practically no interruption.

The oscillogram B represents a dead short circuit. Before the disturbance the line voltage has, as before, a magnitude of U_L. The short circuit occurred at the point (1), the voltage broke down and a short-circuit current I flowed up to the point 2, when the circuit breaker tripped. The line remained unenergised for 0·19 second and it then switched in again. In the meantime the disturbance had not been cleared, the short circuit flowing resulted in a second final opening at the point 4. But the duration of the short-circuit current was limited by the high-speed relay and circuit breaker to an extremely brief period; in fact, the "on" and "off" period was accomplished within 0·4 second, reckoned from the beginning of the fault. The results therefore are claimed to show that by these means successful suppression of the many transient disturbances occurring on electrical systems can be attained.

AGRICULTURAL ENGINEERING SCHOLARSHIPS.—Lord Perry, chairman of the Ford Motor Company, announced recently that, with the approval of the Ministry of Agriculture, the Henry Ford Institute of Agricultural Engineering, at Boreham, near Chelmsford, is offering forty free scholarships for training British boys for careers in agriculture. The scholarships comprise ten that are tenable for three years, ten for two years, and twenty for one year. Each is valued approximately at £175 a year. The intention is to provide theoretical and practical instruction in every branch of farming, with classroom tuition and field work in alternate months, in order to train the boys to become key men in British agriculture.

The Combustion Gas Turbine*

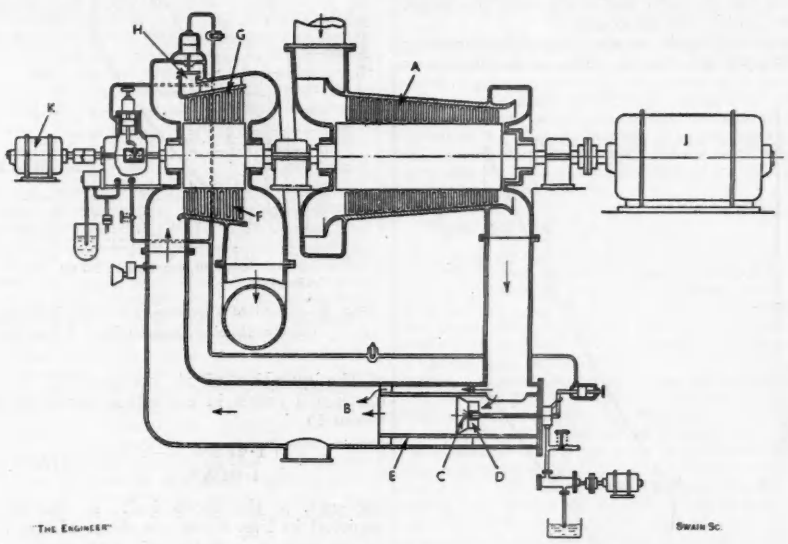
By J. T. RETTALIATA†

IN the early days the main difficulties with the gas turbine unit were the lack of available materials to withstand the high temperatures needed to produce good overall thermal efficiencies, and a compressor of adequate efficiency so as to make the cycle feasible. Only in recent years have these two obstacles been overcome—to-day's better materials enable temperatures of 1000 deg. Fah. to be used; and an axial compressor, upon which years of aerodynamical research have been spent, affords the necessary high-efficiency compressor unit.

Strangely enough, the advent of the steam turbine both inhibited and aided the development of the gas turbine. Interest in the gas turbine waned in favour of the steam turbine, but it is primarily the progress in the development of materials for the latter that has been responsible for the realisation of a commercial gas turbine. Its present stage of development and its future prospects were discussed recently by A. Meyer, whose company, Brown-Boveri, has pioneered in the development of the gas turbine.

GAS TURBINE AXIAL COMPRESSOR UNIT

A modern gas turbine axial compressor unit is shown in Fig. 1. A five-stage reaction type gas turbine A is directly coupled to B, a fifteen-stage axial compressor. Air from the atmosphere enters the compressor where its pressure is raised. Part of the air discharged from the compressor is used for combustion purposes in the oil burner C; the remaining air flowing through the annular space and cooling the products of combustion to a satisfactory turbine inlet temperature. The gas, a mixture of air and combustion products, then expands through the turbine, from which it is exhausted to the atmosphere. The power developed by the turbine is greater than that required by the compressor and the excess power is supplied to the generator D. In order to start the unit from a standstill a motor E is provided to bring the unit up to about 25 per cent. of normal speed, at which point the turbine is capable of driving the compressor.



A, gas turbine; B, axial compressor; C, oil burner; D, generator; E, starting motor

FIG. 1—*The Gas Turbine Power Unit*

The unit is controlled by a speed governor connected to the fuel oil supply. In this way the inlet gas temperature to the turbine is varied, thus changing the power developed by the turbine. An emergency governor actuates a by-pass valve around the turbine when a designated overspeed is exceeded. The turbine and compressor are connected through a solid coupling, which enables their equal axial thrusts to neutralise each other, thus eliminating the necessity of balance pistons.

In an actual example, rated at 23,000 cubic feet per minute of air at standard conditions, the turbine is mounted on a common bed-plate with the compressor. The turbine cylinder is made of molybdenum cast steel and is split on the horizontal centre line. Both inlet and outlet nozzles are situated in a vertical plane; the inlet nozzle being cast in one piece with the upper cylinder half and the exhaust nozzle being cast in one piece with the lower cylinder half. A by-pass connection is furnished joining the inlet and exhaust through a safety valve. The gas turbine spindle is made of a solid chrome-nickel steel forging. The cylinder and spindle blades are made of stainless steel. The cylinder blades are made from a straight rolled section, whereas the tapered spindle blades are milled from solid bar stock. The cylinder blades are held in place by the combined action of spacer pieces and the coincidence of a slot in the blade and a projecting ring in the groove. The spindle blades are securely fastened by the engaging of the upset end of the blade with serrated spacer pieces.

Labyrinth glands are provided where the spindle ends pass through the casing. Sealing air is taken from the compressor discharge and injected at a suitable point along the labyrinth in order to prevent gas from leaking to atmosphere. Separate valves are provided in the sealing lines to both glands.

The turbine spindle is carried by two special roller bearings. Lubricating oil is supplied to individual spray nozzles at a pressure of 25 lb. to 30 lb. per square inch gauge.

A solid coupling is provided to transmit the torque from the turbine to the compressor.

The compressor casing consists of a cast iron cylinder, horizontally split, with inlet and outlet openings directed vertically upward and cast together with the upper half.

The compressor rotor is of forged steel, consisting of two parts: a drum with one shaft end, and a shaft end having a hollow cylinder for the spindle proper. The hollow cylinder is shrunk on to the drum and locked. Labyrinth sealing glands are provided on the rotor ends where the shaft emerges from the casing.

The cylinder and spindle blades for the compressor are made of 5 per cent. nickel steel. The types of root fastening are similar to those described for the gas turbine. The cylinder blades are milled and cam ground to varying sections that increase in area in a radial direction toward the centre of rotation. Such contours are required by aerodynamic theory in order to give a high-efficiency axial compressor.

THE GAS CYCLE

The combustion gas turbine operates on the Brayton cycle, consisting of two isentropic and two isobaric lines.

The theoretical cycle on the pressure-volume plane is shown in Fig. 2. The isentropic compression in the compressor is represented by A B. The isobaric addition of heat in the combustion chamber is shown by B C. Line C D depicts the isentropic expansion in the turbine. The assumption of a closed cycle requires that the exhaust gas be cooled along the constant pressure line D A. The energy theoretically required to compress 1 lb. of air in the compressor is represented by the area E F B A. The energy liberated by 1 lb. of gas expanding in the turbine is shown by the area E F C D. Consequently, the difference between these two areas, A B C D, would represent the theoretical excess energy available for power purposes.

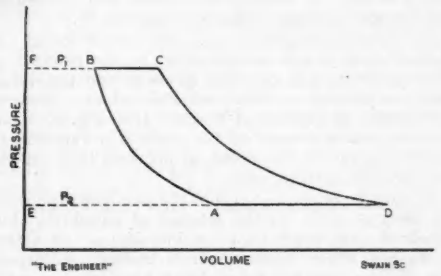


FIG. 2—*The Theoretical Cycle on a Pressure-Volume Plane for the Combustion Gas Turbine*

In a steady flow reversible process the compressive

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* Paper presented at the 1940 Conference of the Oil and Gas Power Division of the American Society of Mechanical Engineers.

† Steam Turbine Department, Allis-Chalmers Manufacturing Company.

and expansive energies per pound are equivalent to area

$$E\,F\,B\,A=\int_{P_2}^{P_1} V_{AB}\,d\,P \quad . \quad . \quad . \quad . \quad (1)$$

and area

$$E\,F\,C\,D=\int_{P_2}^{P_1} V_{CD}\,d\,P \quad . \quad . \quad . \quad (2)$$

respectively; therefore, the excess energy may be expressed as area

$$A\,B\,C\,D=\int_{P_2}^{P_1} V_{CD}\,d\,P-\int_{P_2}^{P_1} V_{AB}\,d\,P \quad . \quad . \quad (3)$$

Using perfect gas relationships, equation (3), upon integration and substitution of limits, becomes, in units of B.Th.U. per pound,

$$\Delta\,h_{ABCD}=\frac{144}{778}\,\frac{k}{k-1}\,P_1\,(V_C-V_B)\left[1-\left(\frac{P_2}{P_1}\right)^{\frac{k-1}{k}}\right] \quad (4)$$

where k=isentropic exponent of fluid in cycle; P_1=pressure at compressor discharge and turbine inlet, pounds per square inch, absolute; P_2=pressure at compressor intake and turbine exhaust, pounds per square inch, absolute; V_C and V_B=specific volumes, at turbine inlet and compressor discharge, respectively, cubic feet per pound.

The theoretical cycle on the temperature-entropy plane is shown in Fig. 3. The nomenclature is

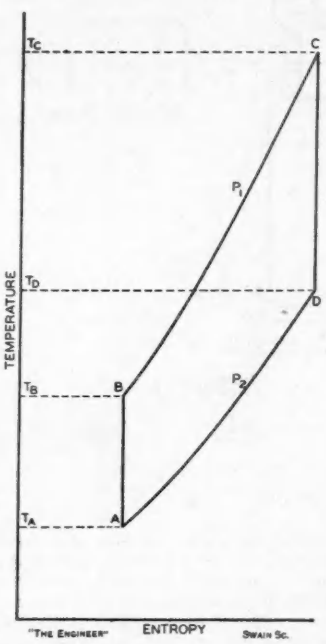

FIG. 3—*The Theoretical Cycle on a Temperature-Entropy Plane for the Combustion Gas Turbine*

similar to that used in Fig. 2. The excess energy, in B.Th.U. per pound, will be

$$\Delta\,h_{ABCD}=c_p\,[(T_C-T_D)-(T_B-T_A)] \quad . \quad . \quad (5)$$

where c_p=specific heat of fluid at constant pressure; and T_A, T_B, T_C, T_D=temperatures, in degrees Fahrenheit absolute, at compressor intake and discharge, and turbine inlet and exhaust, respectively.

Referring to equation (5), the excess energy in B.Th.U. per pound is equivalent to the product of the specific heat at constant pressure and the difference, expressed in degrees Fahrenheit, between the lengths of the lines A B and C D in Fig. 3. Thus the net useful output of the cycle is a function of the divergence of the constant-pressure lines on the temperature-entropy plane.

It must be remembered that the previous discussion on the gas cycle, in the interest of simplicity, has involved only theoretical considerations. In actual operation other factors which reduce materially the output energy must be taken into account when ascertaining the real excess power obtainable.

For example, the efficiencies of the turbine and compressor must be considered, and also the drop in pressure between the compressor and turbine. The isentropic exponent k must be the ratio of the mean value of the variable specific heats for the temperature ranges involved. There must be a further, although slight, correction made for the larger quantity of gas flowing through the turbine due to the fuel added for raising the temperature of the air. The true excess energy then will involve these modifications and will be less than that given by equations (4) and (5).

A theoretical and actual gas turbine cycle are shown in Fig. 4 on a combined temperature-entropy and enthalpy-entropy diagram for air, based on the Partington and Shilling equations for variable molar specific heat.

The incorporation of the enthalpy scale at the right facilitates the use of the diagram by eliminating the operation, shown in equation (5), of multiplying the specific heat at constant pressure by the absolute temperature, the product being enthalpy. For convenience, the temperature scale reads directly in degrees Fahrenheit.

For purposes of simplification the composition of the gas in the turbine is taken as the same as the air in the compressor. This is essentially correct for a power cycle as the amount of fuel added to raise the temperature of the air is less than 1 per cent. of the quantity of air flowing through the compressor.

The theoretical cycle is shown by A B C D in Fig. 4, whereas A B′C′D′ represents the actual cycle after losses have been taken into account.

Assuming the fuel required to be 1 per cent.

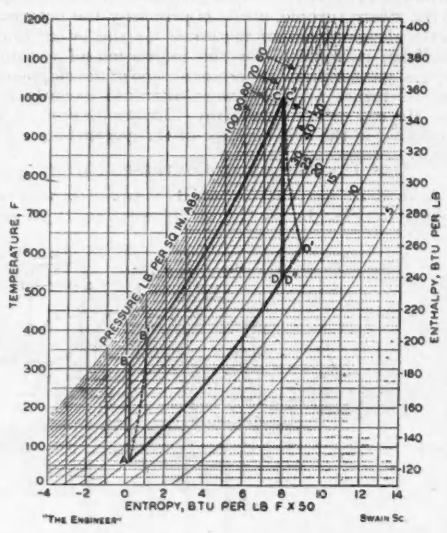

FIG. 4—*Combined Temperature-Entropy Enthalpy-Entropy Diagram Showing Theoretical and Actual Cycles*

of the quantity of air compressed, the effect of losses will result in an actual excess energy equivalent to

$$\left[\frac{1{\cdot}01\,\Delta\,h_{C'D'}-\Delta\,h_{A'B'}}{1{\cdot}01\,\Delta\,h_{CD}-\Delta\,h_{AB}}\right]\times 100 \quad . \quad . \quad (6)$$

per cent. of the theoretical. In the actual cycle depicted in Fig. 4, 63 per cent. of the theoretical excess energy is not realised, thus demonstrating the importance of a highly efficient turbine and compressor, and also the necessity of maintaining small pressure drops in the combustion chamber.

In the example just discussed the composition of the gas in the turbine was assumed to be identical with that of the air in the compressor. Some cases arise, however, wherein the turbine receives gas of an entirely different composition, such as products from a chemical process. In these instances the

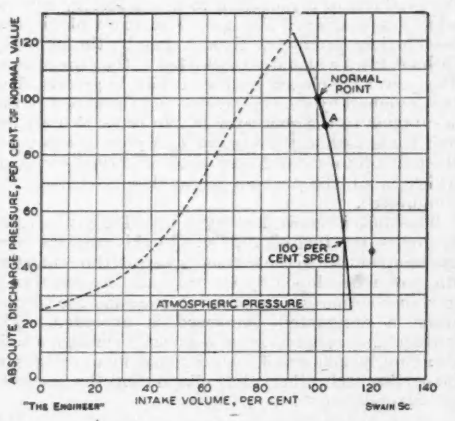

FIG. 5—*Axial Compressor Characteristics*

energy per pound of expanding fluid cannot be obtained from Fig. 4, but must be determined from the thermo-dynamic properties of the particular gas in question.

AXIAL COMPRESSOR CHARACTERISTICS

As mentioned previously, the governing of a power unit is accomplished by controlling the quantity of fuel supplied to the combustion chamber and thus varying the temperature of the gas entering the turbine. Other factors remaining constant, the absolute pressure at the turbine inlet would vary approximately as the square root of the absolute inlet temperature.

The characteristics of the axial-flow compressor are such that when operating at constant speed the volume of air at the intake varies only slightly with discharge pressure, as shown in Fig. 5. An examination of the curve will reveal that as the discharge pressure falls a small increase in suction volume results.

When the power required by the compressor is exactly balanced by the power delivered by the turbine—that is, when the excess power is zero—the temperature at the turbine inlet will be about 650 deg. Fah. Consequently, using the relationship between pressure and temperature stated previously, and correcting for the slight increase in gas quantity at reduced pressure, the absolute inlet pressure under this new condition will be approximately 10 per cent. less than the design value.

Therefore, the entire operating range of the unit, from no load to full load, is confined to that portion of the curve (Fig. 5) included between the normal point and point A. Thus, regardless of the electrical load, the unit operates very nearly at design values of pressure and gas flow.

Although a reaction turbine and an axial compressor bear a physical resemblance to one another, the design problems associated with each are quite different. For instance, in the case of a fluid expanding in a turbine, the reheating effect, caused by friction in the blade passages, results in an overall internal efficiency better than the stage efficiency, whereas in a compressor the reheat due to friction has a negative effect, and consequently depreciates the overall efficiency to a value less than the individual stage efficiency.

The axial type of compressor has a limited stable operating range at any given speed. At full speed stable operation will only exist down to about 90 per cent. volume, beyond which point the compressor will commence "pumping." This phenomenon occurs at reduced volumes because then the axial velocity component causes the air to enter the blades at an extremely glancing angle, which results in loss of contact on the backs of the blades and subsequent unstable conditions. The axial compressor may be operated stably at reduced volumes, however, by decreasing the speed. In Fig. 5 the region of unstable operation is represented by the area to the left of the broken line.

In contrast with the type of operation exhibited by the axial compressor is that of the centrifugal compressor with its stable range extending to approximately 50 per cent. volume or lower at full speed. However, owing to its lower efficiency the centrifugal compressor, unless it were elaborately water cooled, could not replace the axial type for the application under consideration. Furthermore, due to the fact that temperature and not quantity control is used on these units and, as previously discussed, the operating range is limited to a relatively small portion of the pressure-volume curve, the axial type of compressor is well adapted to this class of service.

(To be continued)

Skilled Labour

THE following is the text of the letter referred to in a Seven-Day Journal Note and a Leading Article on other pages of this issue. The letter was signed by Mr. A. V. Alexander, First Lord of the Admiralty; Mr. Herbert Morrison, Minister of Supply, and Lord Beaverbrook, Minister of Aircraft Production, and was sent on July 20th to 9000 firms in the engineering industry:—

The country is at war with an enemy who has devoted six years of concentrated effort to organising the maximum production of war equipment from the resources at his disposal. We have to counter that effort.

We can no longer think of personal profit or the future of a particular firm or industry. We must think of the nation's interest alone.

One of the most important jobs to be done by you is to assist in the reorganisation of man power in the engineering and allied industries. Every skilled engineer in the country should be employed on work of the maximum skill of which he is capable.

There is an immediate need for skilled workmen in many factories to bring into production plant recently installed or still idle during night shifts, and to give some relief to those who have been working exceptionally long hours. The need will grow as further plant becomes available. It is therefore essential that in every engineering establishment up-grading and "training up" should take place to the fullest extent practicable.

Thousands of semi-skilled workers will have to be trained. Government training schemes have already been expanded and are being expanded still further. These alone cannot be enough. The greater part of training must be undertaken by employers themselves in their own workshops. The further expansion of Government schemes requires skilled instructors. Every additional instructor must come from industry, but each instructor can produce many semi-skilled men a year.

The Minister of Labour and National Service has set up an organisation to ensure that the best use is made of available man power. Although many of the large force of inspectors are already at work, and the remainder are being appointed as quickly as possible, their task of visiting the

many thousands of firms concerned will take a long time. Meanwhile, you should, on your own initiative, take any of the following steps that you can and take them immediately. If you have already taken such steps you should look into the matter afresh to see whether there is anything further you can do :—

(i) Examine your whole labour structure with the object of expanding the productive effort of the men employed by you. By up-grading men of less experience release the most highly skilled workers either for additional output from your own factory or for transfer elsewhere.

(ii) Consider how far you can "break down" operations so that the jobs can be done by workers of less skill.

(iii) Establish within your factory facilities for training new entrants to the industry and training up existing employees to skilled work to the maximum degree compatible with efficiency.

(iv) Reconsider any demands for skilled labour you have already made on the Employment Exchange and cut them down to the minimum necessary in the light of the preceding paragraph. Also, report to the Employment Exchange the labour you can release even temporarily.

(v) Welcome and give every possible assistance to the officers of the Ministry of Labour if they visit your works. They will ask for your co-operation in any proposals they may have to make, but they will have in mind the needs of the nation rather than the needs of any particular firm. Where Labour Supply Committees have been set up you will have an opportunity of stating your case to the Committee if you do not agree with the inspector. If you feel that the proposals made will interfere with the work you are doing for a Production Department, and if you are unable to reach agreement with the Ministry of Labour officials, the Area Officer of the Production Department is available to advise you.

(vi) Assist, if so requested, in locating men suitable to work as instructors in Government training centres.

If you are in doubt about the relative importance of any work you are doing you should consult the Area Officer of the Department for which the work is being done, or, if there is no Area Officer concerned with the work, you should consult the Employment Exchange Manager.

If we do not all pull together we are in danger : the matter was never more urgent—act now.

BRITISH STANDARDS INSTITUTION

All British Standard Specifications can be obtained from the Publications Department of the Institution at 28, Victoria Street, London, S.W.1. The price of each specification is 2s. 3d. post free, unless otherwise stated.

COPPER ALLOY BARS

Revised specifications have just been issued for the following :—

B.S. 218.—Brass Bars and Sections, suitable for Forgings and Drop Forgings.
B.S. 249.—Brass Bars (High-speed Screwing and Turning).
B.S. 250.—High-tensile Brass Bars and Sections.
B.S. 251.—Naval Brass (Admiralty Mixture) Bars and Sections.
B.S. 252.—Naval Brass (Special Mixture) Bars and Sections.
B.S. 369.—Phosphor-bronze Bars or Rods for General Purposes.

The revision has been effected to bring these specifications up to date and there are two outstanding features. The first is that Standards 218, 251, and 252 have been amplified by the addition of a separate section to provide for forgings. The other is the fact that the revised specifications now supersede a number of Aircraft Specifications in the B series as follows :—

3 B 1.—High-tensile Brass Bars.
3 B 6.—Naval Brass Bars.
3 B 11.—Brass Bars suitable to be Brazed or Silver Soldered.
3 B 13.—Brass Bars (High-speed Screwing and Turning).
D T D 78.—Phosphor-bronze Bars.

TESTING FUSION WELDS, WELDED JOINTS AND WELD METAL

(B.S. 709.)—This British Standard was first issued in November, 1936, but was then confined to the standardisation of the bend test as applied to welds and welded joints. Since that date the use of welding in industry has made further strides, and the present revision has been undertaken in order to include standards for other forms of test and to co-ordinate and simplify the various tests which are already in existence. The advantages resulting from the adoption throughout the industry of similar test pieces and the same methods of testing so as to enable test data to be readily compared and correlated are obvious. It is hoped therefore that the standard will serve an exceedingly useful purpose. In the specification a general indication is given of the use to which each of the different tests may be put, but it does not purport to lay down when any particular test should or should not be used on a given structure, or what the test results should be. Such requirements are matters to be dealt with in the preparation of each particular specification in which welding forms a part.

Markets, Notes and News

The prices quoted herein relate to bulk quantities. Unless otherwise specified home trade quotations are delivered f.o.t. Export quantities are f.o.b. steamer

Our June Exports

The Board of Trade returns in their abbreviated form give the value of the total exports of goods in June as £36,211,458, compared with £45,499,645 in May. The June figure, however, showed a decrease of £3,683,798 from the value of the exports in June, 1939. The decrease is to be attributed largely to the concentration of home production upon the war effort in June, and the loss of some markets through enemy action. The exports of coal in June at £2,859,950 were £833,724 lower than in the same month last year, whilst iron ore and scrap was exported to the value of £899, which is a decrease of £35,863 on the corresponding period of 1939. Non-ferrous metalliferous ores and scrap exports were also considerably lower last month at £22,347, a drop of £154,390 compared with the June, 1939, exports. The exports of coke and manufactured fuel reached in value £194,548, a fall of £132,264 compared with the same month last year. The value of iron and steel and manufactures thereof exported in June reached £3,076,066, a decline of £162,576 from the 1939 figure. Non-ferrous metals and manufactures thereof were exported to the value of £1,176,355, a fall of £49,140 on the exports in June, 1939, whilst exports of cutlery, hardware, implements and instruments totalled in value £773,354, which was £59,316 below the June, 1939, figure. Electrical goods and apparatus were exported to the value of £1,043,846, which was also less than in June last year, the drop being £32,530. Machinery exports amounted to £3,165,146, but this also showed a loss on the figure for June last year of £1,277,208. Exports of vehicles, including locomotives, ships, and aircraft, at £2,826,619 were lower by £1,052,267 than the value of the exports in June, 1939.

Imports in June

The total of our imports in June showed a considerable reduction from the figures for the previous month, the figures being £90,779,141 and £105,552,962 respectively. Iron ore and scrap brought into the country totalled £1,674,557, an increase on June, 1939, of £406,395, whilst non-ferrous metalliferous ores and scrap were imported to the value of £1,666,404, a rise of £318,581 over the imports for the previous June. In the case of imports of iron and steel and manufactures thereof, which totalled in value £2,008,289, there was an increase of £187,148 on the value imported in June, 1939. Non-ferrous metals and manufactures thereof also reached a higher value at £4,868,165, which was £1,397,820 greater than for the imports in June, 1939. Cutlery, hardware, implements, and instruments, on the other hand, were imported to the value of £378,245 in June, which was £178,332 less than the value of similar importations in June last year. The imports of electrical goods and apparatus last June amounted in value to £185,692, or £75,106 less than similar items in 1939. The imports of machinery at £2,694,038 were £212,556 more than those in June last year. The value of vehicles imported, including locomotives, ships, and aircraft, at £2,655,428 was £2,291,765 above the imports in June, 1939.

The Pig Iron Market

The gradual expansion in the demand for pig iron has created an impression of tightness in some sections of the market and has certainly led to a more careful consideration of applications for licences. It is only in foundry iron that there is any suspicion of quiet conditions, and this is confined to the high-phosphoric foundry grades. Consumers of this description find no difficulty in obtaining all they require, but as it is largely used by the light castings makers, who are experiencing a dull period of trading, there is no excessive pressure to secure supplies. Reports that this industry would play a greater part in the war effort have been disappointed and the majority of the foundries are working short time. On the other hand, the demand for low-phosphoric foundry iron is in excess of supply and as this quality continues to be taken up extensively by the engineering firms engaged upon war work the quantities available are scarcely sufficient to meet consumers' full requirements. In consequence a considerable amount of hematite iron is being used as a substitute. The situation in the hematite section has not improved during the past few weeks, and although consumers are receiving their requirements the situation has become stringent. Stocks in makers' yards have been largely liquidated, and deliveries to the consuming industries are being carefully rationed by the Control. It is probable that there will be some expansion of the output of this description and in the meantime supplies for unessential purposes are likely to be severely curtailed. On the North-East Coast the producers of pig iron are concentrating almost entirely upon the production of basic, and foundry supplies come into the district principally from the Midlands. Practically all the business formerly done in Cleveland foundry iron with Scottish foundries is now being taken by Midland producers. In the Midlands there has been some dissatisfaction that consumers have not been able to obtain the particular grades of iron wanted, and an Advisory Panel has been established by the Control to help ironfounders out of their difficulties. In Lancashire good quantities of pig iron have been taken up by the munitions industries, and there has been an improved demand from the textile machinery makers, who hope to expand their export trade, and for this purpose licences seem readily obtainable. The Scottish producers are maintaining regular supplies to their customers, and although there are no stocks at the furnaces or at consumers' works the situation is not unsatisfactory.

The North-East Coast and Yorkshire

Activity at the works in the North-East Coast district shows no signs of slackening and all available plant is being brought into service. Practically all the orders now being dealt with by the steel makers are concerned with the war effort. The consuming industries are pressing for increased supplies of steel and huge quantities are being taken up by the general engineering concerns, shipbuilders, tank makers and a host of other trades that have been diverted from their normal peace-time production to national service. The insatiable demand for joists, sections and plates from constructional engineers has in no way slackened, and in spite of the efforts of the steel works, backed by the supervision of the Control, some delays in delivery have been reported. This is not surprising considering the enormous demand which the steel industry is meeting, and undoubtedly it would be much worse if it were not for the careful supervision of distribution by the Control. The use of steel for building construction, except under licence, is now being rigidly banned, and it would appear that steel supplies are now being utilised for national purposes to an extent approaching 100 per cent. The quantities of steel passing to the shipyards reaches an impressive total and all the yards are fully occupied. A large tonnage of billets and sheet bars is being produced by the British works and recently this output has been supplemented by substantial importations of American semis. These have reinforced the stocks already in the hands of the re-rollers, which had fallen to a somewhat low level. Production by the re-rolling works has been maintained at a high rate, but even so it has been difficult to meet the heavy demand for small bars and sections and strip. The Yorkshire steel industry has been hard pressed for some months to meet the demand. As makers are now receiving explicit instructions from the Control regarding the priority of orders, little steel is passing to any firms except those engaged on war work. All the mills are being operated full time and at Sheffield large outputs are being obtained. The demand for aircraft steel, tool steel and other special steels is growing and it is probable that more crucible furnaces are now in action than for many years.

Copper and Tin

The copper market has developed an easier tone, and in the United States the price has receded to 10·25c., f.a.s. The American producers, however, have retained the official domestic price at 11·50c., although there have been transactions at 10·75c. and the Customs smelters appear to be willing to accept 10·87½c. The weakness in the market may be attributed to the lessened demand as a result of so many important copper consuming countries being overrun by Germany. The domestic copper trade in the United States also has become much quieter and comparatively little interest has been shown in this side of the market. India has been of late one of the most persistent inquirers for copper and Swiss consumers also have tried to effect purchases. The trouble with the latter country, however, is the difficulty of arranging for shipments, since the metal has to pass through the British contraband control and German occupied territory, with the result that there is considerable uncertainty that it will ever reach its destination. It is reported, however, that a certain amount of copper has found its way to Switzerland in spite of obstacles. In Great Britain the situation is satisfactory and consumers are receiving supplies with regularity. The consumption of copper must be at a high level, but as no statistics can be published it is impossible to say what quantities are going into use. . . . A rather uncertain tone has characterised the tin market of late and prices have varied rather sharply. The backwardation also has moved between 10s. and 30s. per ton. It is believed that little of the 75,000 tons of tin which the American Government is to purchase during the next twelve months has yet been bought. The fixing by agreement of the price which the American Government will pay at 50c. has had the effect of creating a steadier tone in the American market, and it is expected that this figure will become the unofficial maximum price.

Lead and Spelter

Large supplies of lead continue to reach this country with regularity and the position remains satisfactory. Most consumers are fully employed upon war work and have no difficulty in obtaining their supplies. The position has distinctly improved compared with that of a few months ago, and a certain amount of metal can now be allocated for the export trade and uses which are not essential to the war effort. Amongst consumers, the cable works are exceedingly well employed, and considerable quantities of lead are being used for the manufacture of batteries. On the other hand, the demand for lead pipes and sheets is not particularly strong, owing chiefly to the slackness in the house building trade. It is reported that considerable economy is being exercised in the use of lead pipes, &c., in the many factories which are now being erected, and this strengthens the belief that the authorities anticipate that after the war there will be a much greater factory capacity than is likely to be required. . . . Whilst there is no actual tightness in the spelter position, greater care is exercised in the issue of licences than in the case of lead. It is reported that it is not always easy to obtain high-grade metal when required, but this is somewhat surprising, since most of the spelter in this country comes from Empire sources, which produce only high-grade metal. All the British consuming industries are fully employed on work of national importance. The galvanisers are as busy as their supplies of semi-finished steel will permit, and their requirements of spelter have been heavy. Of late, however, there has been some falling-off in buying by this industry, presumably because of the substantial purchases made a short time ago. The die castings makers are also well occupied on Government work, and large tonnages of these products are passing into the production of aircraft and mechanised equipment. Export licences are not easy to obtain and this has interfered to some extent with the satisfaction of a rather active demand from India. In the United States the market is steady, but it is noticeable that consumers there are placing long-term contracts on an average price basis.

Notes and Memoranda

Rail and Road

THE OPENING OF THE BAGHDAD RAILWAY.—In a Journal note published in our issue of July 19th, we referred to the only tunnel on the main line, which was constructed by Balfour, Beatty and Co., Ltd., as having a length of 1000ft. This should read 1000 m.

VEHICLES IN AIR RAIDS.—The Minister of Home Security desires to make it clear that drivers of vehicles may proceed after an air raid warning has been given, if they have good reason for doing so. If an air raid warning is given at night headlamps should be extinguished, but side and rear lamps should be kept alight while the vehicle is on the road.

PURCHASE OF NEW MOTOR VEHICLES.—A Ministry of Transport Order prohibits the purchase of new unregistered motor vehicles without a licence from the Ministry. Vehicles for export, certain specialised vehicles such as tramcars, agricultural tractors, mowing machines and motor-cycles not adapted for the carriage of goods, are exempted from the Order. Consultations are in progress between the Board of Trade and Mr. W. E. Rootes, President of the Society of Motor Manufacturers and Traders, as to a plan for exporting new vehicles in stock through the export group of the motor industry set up by the Export Council.

NEW YORK ELEVATED RAILWAYS.—Demolition of about 24 miles of elevated railway lines in New York City is to be undertaken in the near future. The greater part will consist of the Ninth Avenue Elevated through the entire length of Manhattan Island. Construction of the first elevated railway began in 1867. The original Ninth Avenue line was double track and was operated with 15-ton steam locomotives. In 1893 new 24-ton locomotives were bought, the structure was strengthened, and a third track was added to permit the operation of express trains in the busy hours. The first electric train was operated on the Second Avenue line in 1902.

RAILWAY PHOTOGRAPH EXHIBITION.—The British railways are making an immense contribution to the national war effort, and although they have been taken over by the Government so that national needs may come first, they still have to fetch and carry to maintain the life of the country. An exhibition of photographs opened recently at Charing Cross Underground Station outlines in a striking manner the many activities of the railways in time of war. The Exhibition has eleven sections dealing with (1) Preparation, (2) Protection, (3) Evacuation, (4) Black-out, (5) Night Work (6) Munitions, (7) Weather, (8) Refuge, (9) Troops, (10) Overseas, and (11) Effort.

LAND SPEED RECORD CAR.—It has often been a matter of conjecture as to what happens to old racing and record-breaking motor-cars. One of the most famous of such cars was the 1000 H.P. Sunbeam, which, driven by the late Sir Henry Segrave, set up a world's record of 203·7 miles an hour at Daytona Beach in 1927. We learn that this remarkable old car has been carefully preserved by Sunbeam Commercial Vehicles, Ltd., at the works where it was originally built and lately has been lent to Loughborough College, at the request of the Principal of that College, Dr. Herbert Schofield. It has been placed on view with other "museum pieces" for the benefit of the students.

ILLUMINATED ROAD SIGNS.—A new device has been experimentally adopted in America in connection with illuminated guide lines for motor traffic at night. It consists of a phenolic plastic material, made by the Monsanto Chemical Company, having a red transparent surface which is embedded in an existing central road division so that it is flush with the road surface. Under this covering, electric lighting equipment, similar to Neon tubing, emits a light which it is claimed can be seen through heavy fog, rain or dazzling oncoming headlights. The surface has been tested for sixteen months and it is estimated that three million vehicles have passed over it without noticeably wearing the surface. Units are made in 30in. and 60in. lengths.

ELECTRIC MINING LOCOMOTIVE.—An Ohio mining company has placed in service a locomotive having eight wheels mounted in four axle-less trucks. Each truck consists of two wheels in tandem, driven by a single motor. The arrangement ensures less friction on curves, and higher draw-bar pull. This company has also installed the newest kind of mining sub-station. It is as portable as the cars themselves, is small enough to go wherever they go, thus following the load, and needs no additional protection from falling objects. The transformer, ignitron rectifier, and the controller of Westinghouse manufacture are mounted on two cars that can be drawn by a mining locomotive to an unused siding in a worked-out portion of the mine near the scene of mining operations. Electrical connections can then be made and service begun. Especially important is the low height—only 46in.

Air and Water

A MINISTRY OF AIRCRAFT PRODUCTION APPOINTMENT.—It is officially announced that the Minister of Aircraft Production, Lord Beaverbrook, has appointed Mr. W. L. Stephenson, the chairman of F. W. Woolworth and Co., Ltd., to be Director-General of Equipment in the Ministry of Aircraft Production.

OFFICERS FOR R.A.F. GROUND DUTIES.—The Air Ministry announces that officers are needed by the Royal Air Force to carry out administrative ground duties. Commissions in the R.A.F.V.R. are therefore being offered for the duration of war to men with suitable qualifications. Applicants must be between the ages of thirty-two and fifty, and must be either ex-officers or must have held good executive positions in civil life to prove their administrative ability. Sound education is essential. Those selected for commissions will enter the R.A.F.V.R. as pilot officers on probation, with pay beginning at approximately £215 a year, plus family and other allowances. There will be opportunities for promotion. Candidates should write to the Air Ministry (S.7.(E)5), Adastral House, London, W.C.2, for application form 1020.

CANADIAN WELDED TANKER.—The largest all-welded oil tanker ever built in Canada was recently launched at the Marine Industries Shipyard at Sorel. She is the "Lakeshell," constructed for the Shell Oil Company of Canada, and measures 259ft. in length, 43ft. 10in. in breadth and 22ft. in depth.

CONTROL OF MAGNESIUM.—The Minister of Aircraft Production has made the Control of Magnesium (No. 1) Order, 1940. The Order provides that magnesium and magnesium alloys, whether unfabricated or in the form of billet, block, powder, slab, or stick, shall not be bought, sold, or used except under licence.

NEW MINEFIELD.—The Admiralty has proclaimed that an area extending from the north-west coast of Cornwall, between Hartland Point and Trevose Head, to the limit of Irish territorial waters between Minehead and the Tuskar lightship, is dangerous owing to mines. Ships wishing to enter the Irish Sea or the Bristol Channel must pass round the North of Ireland.

CANADA'S SHIPPING.—According to the annual report of the Canadian National Harbours Board, 40,894 vessels with a tonnage of nearly 40,000,000 arrived at Dominion ports in 1939, compared with 40,467 with a tonnage of just over 40,000,000 the previous year. The cargo tonnage, inward and outward, totalled 29,694,157 in 1939, compared with 31,732,877 in 1938.

BRITISH CONTRABAND CONTROL.—In the period from July 7th to July 15th the British Contraband Control seized about 10,000 tons of suspect goods destined for the enemy. The goods included 2300 tons of metals, 5000 tons of textiles, 2350 tons of timber and 180 tons of chemicals. The control has seized 700,000 tons of suspected contraband since the beginning of the war.

REQUISITIONING OF FRENCH SHIPS.—The Ministry of Shipping announces that French merchant ships in United Kingdom ports are being requisitioned under the Defence Regulations by the Government. At the end of the war compensation will be paid for their use and the ships will be returned to France. During the war they will sail under the British flag, but they will also fly the French flag.

MERCANTILE LOSSES DUE TO ENEMY ACTION.—During the week ended Sunday, July 14th, inclusive, the total British tonnage lost was 32,963, consisting of nine merchant ships. Four Allied and six neutral vessels of tonnage 7335 and 20,734 were also lost by enemy action in this period. The total was nineteen ships with a tonnage of 61,032, a little more than half of the tonnage loss during the previous week and less than one-third of the highest total reached in any one week during the present war.

MR. G. R. CRITCHLEY.—The honorary degree of Master of Arts has been bestowed on Mr. George Richard Critchley, general manager of the Liverpool and Glasgow Salvage Association. A recognised authority on all matters affecting marine casualties, Mr. Critchley took an important part in the raising of H.M. submarine "Thetis." The operations are described in a paper by Mr. Critchley, which was published in the "Transactions" of the Institution of Naval Architects and was reprinted recently in THE ENGINEER.

MESSERSCHMITT 110 AS A BOMBER.—Although it was known that the Messerschmitt 110 machine could be converted for use as a bomber, until recently it has not been seen in action in this capacity. Sixteen converted aircraft attempted a dive-bombing attack on a convoy some time ago, but they were broken up by British fighters, one being shot down and another damaged. The conversion presumably entails a reduction in the machine's range and striking power, in order to accommodate a bomb load.

COMPULSORY LIFE-SAVING JACKETS.—The Minister of Shipping has announced that he is now making compulsory the use of a life-saving waistcoat by seamen on duty. Experience of ships sunk by enemy action has shown that sufficient time has not been available in many instances for the crews to don their life-jackets. Tests were therefore made with a buoyant waistcoat for members of the crews of sea-going ships when the vessel is in a dangerous area. All ships carry a sufficient number of standard pattern life-jackets for all on board, but the life-saving waistcoat would be an additional emergency appliance. The waistcoats are made of cotton drill and weigh 16 oz. each, and are quilted on each side of the front and across the shoulders at the back, each section being filled with kapok. Tapes are fastened to the back of the waistcoat to enable it to be adjusted around the waist of the wearer if necessary, and they are made having twice the buoyancy necessary to support a man. Their cost is roughly 10s. each.

Miscellanea

COMPULSORY SALVAGE.—A compulsory direction has been issued by Mr. Herbert Morrison, Minister of Supply, to all local authorities with a population of over 10,000 requiring the operation of satisfactory collection schemes for paper, bones and metal.

TRADING WITH THE ENEMY: FRANCE AND FRENCH TERRITORIES.—The Board of Trade has given public notice that the whole of French territory in Europe (including Corsica), Algeria, the French zone of Morocco and Tunisia are enemy territory for the purpose of the Trading with the Enemy Act. It is accordingly a punishable offence to have commercial, financial, or other intercourse or dealings with or for the benefit of any person resident or carrying on business in any of that territory, or any body of persons carrying on business in any place, if and so long as the body is controlled by a person resident or carrying on business in that territory. Inquiries on the subject should be addressed to the Trading with the Enemy Branch, Alexandra House, Kingsway, London, W.C.2.

THE LATE MR. CHARLES KER.—We regret to have to record the death of Mr. Charles Ker, at the age of eighty. He was chairman of the Clyde Valley Electrical Power Company, Chairman of the Scottish Committee of the London Midland and Scottish Railway Company, and a director of the Mirrlees Watson Company, Ltd., and Mirrlees, Bickerton and Day, Ltd.

NEW AUSTRALIAN MUNITIONS FACTORIES.—The erection of a new explosives and filling factory, duplicating the existing factory at Melbourne, on a site of 3000 acres near Adelaide, has been authorised by Mr. Menzies, the Australian Prime Minister. The South Australian Government is providing a railway connection for the factory, and also electricity, water, sewerage, roads, engineering and technical services. Nearer Adelaide will be built a factory for brass cartridge cases and fuses. Other extensions are in progress and a gun and tank programme is to be announced.

ENGINEERING SCHOLARSHIPS.—Following an examination held in London last month, in which boys from public and secondary schools took part, F. M. Turner, of Birkenhead School; D. A. MacWilliam, of King's College School; and G. E. Mee, of Chigwell School, have been awarded engineering scholarships worth £600 each by R. A. Lister and Co., Ltd., of Dursley (Glos). The winners will be given a 4½ years' course of training in the machine shops and drawing-offices in the Lister engineering works at Dursley. During their training they will be paid salaries which start at £135 a year and rise to over £200.

GLASS FIBRE COVERED WIRE.—An article in the *Electrician* describes glass fibre insulated conductors covered with a material known by the trade name "Lewcoglass." The insulation is 100 per cent. pure glass. Available in the form of cloths and tapes, and also as a fibrous covering for winding wires, the glass fibre is claimed to withstand temperatures which would quickly destroy cotton, silk, enamel and similar organic materials. Furthermore, as a wire covering, glass is resistant to acids, except hydrofluoric acid, to oils and to moisture; it is flexible and, when specially treated, is claimed to withstand abrasion reasonably well.

CHLORINATION OF WELLS.—For some time past consideration has been given by the Metropolitan Water Board to the arrangements necessary to give effect to the principle that all well waters pumped directly into supply should be covered by chloramine treatment as a standard protective measure. All the Board's river supplies and a number of wells have already been safeguarded, but certain wells in the Kent and Northern areas still remain to be dealt with. The Ministry of Health has recommended that all water for domestic purposes should be safeguarded by chlorination in present circumstances should the necessity arise. For this purpose the Board was recommended at a recent meeting to install chloramine treatment plant at one station and super-chlorination plant at six other stations, at a cost of £8130. The Board was also asked to approve a sum of £3277 for joining the ends of mains in the Eastern and Kent areas to provide alternative means of supply in case of damage during air raids.

PERSONAL AND BUSINESS ANNOUNCEMENTS

THE FOUNDRY EQUIPMENT GROUP and the Furnace Export Group have been established at Room 242, Grand Buildings, Trafalgar Square, London, W.C.2. Mr. G. E. France, of Augusts, Ltd., Halifax, is chairman of both groups, and Mr. K. W. Bridges is secretary to them both.

THE BRUSH ELECTRICAL ENGINEERING COMPANY, Ltd., Loughborough, informs us that manufacturing facilities for the Brush-Koela gas producer have been reorganised, and that production is now proceeding on a continuous basis. The company is now in a position to give expeditious delivery.

CONTRACTS AND ORDERS

The Editor is always happy to print short announcements of contracts and orders in this column provided they are sent to him in time to have news value and that they are likely to interest readers.

MR. YORATH-LEWIS, M.I. Mech. E., A.M.I.E.E., has received an order for a 400 lb. working pressure Lewis boiler of 4000 lb. capacity to be used for testing purposes and for general steaming service.

CATALOGUES

J. PAYEN, Ltd., Church Street, Chiswick, W.4.—Supplementary gasket guide.

B.E.N. PATENTS, Ltd., Hughenden Avenue, High Wycombe, Bucks.—Compressed air equipment catalogue.

BRITISH ALUMINIUM COMPANY, Ltd., Raven Hotel, Castle Street, Shrewsbury.—A new booklet on aluminium tubes and pipes.

E. H. JONES (MACHINE TOOLS), Ltd., Edgware Road, The Hyde, N.W.9.—Booklet describing Cincinnati power brakes and shears.

ALUMINIUM UNION, Ltd., Adelphi, Strand, London, W.C.2.—"Aluminium Technique," dealing with the various aspects of the working of aluminium.

BIRMINGHAM ELECTRIC FURNACES, Ltd., Tyburn Road, Erdington, Birmingham, 24.—Particulars of electric furnaces for general heat treatment work.

ELLIOTT BROTHERS (London), Ltd., Century Works, Lewisham, London, S.E.13.—A new publication dealing with a disappearing filament-type optical pyrometer which has been designed for measuring very high temperatures, particularly in cases where it is impracticable to employ thermo-electrical pyrometers.